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THE ELECTRIC LIGHTING ACT.

(*Continued from page* 128.)

In the "regulations for safety" proposed by Mr. Fletcher Moulton in the *Provisional Orders* under the Electric Lighting Act, and which we gave in full last week, will be seen the following strange expression: "per *square inch of section* of a *pure copper wire* of *equal conductivity*." We presume that Mr. Moulton means per *square inch section* of *pure copper*, or of a *larger section* of *impure copper* giving *equal conductivity*. Pure copper of equal conductivity appears rather paradoxical, for if the conductivity were not equal it would not be pure copper. In regard to the distributing mains and the current to be conveyed by them, we do not think that a conductor having a square inch section is large enough for 2,000 ampères. 2,000 ampères of current would, if the wire were cylindrical and suspended in *air*, and had exactly 1 square inch section, give a temperature about equal to that of boiling water. A cylindrical wire having $\frac{1}{10}$th of this section, and traversed with $\frac{1}{10}$th of the specified current would take a much lower temperature, although the heat developed in each unit of section would be the same, because in the smaller wire the radiating surface is larger in proportion to the section. On the other hand, a much larger conductor would get very much hotter if each square inch were traversed by the same ($2{,}000^a$) current, simply because, while providing an internal heat development proportional to the square of the diameter, a radiating surface is provided only proportional to the diameter.

This regulation (*a*) would have been better framed had it read "the maximum current for distributing or service lines shall be such that the temperature of the copper shall never exceed so many degrees," &c. As it is now stated, it is rather unsafe.

Regulation (*b*) is weak. The leakage permissible should be proportional to the current. Thus, as it reads, if the current be 10 ampères, the whole of it may be lost; if 2,000, then only $\frac{1}{2}$ per cent.; if 100 ampères, the loss per mile may be 10 per cent. A percentage of loss would have been a better way of stating the rule.

The conductors themselves will have to be treated very much in the manner of submarine cables, both in respect to their insulation and protective sheathing. It seems a pity that some other method cannot be devised for regulating the current strength other than by a fusible plug or safety fuse.

The positive and negative poles within the consumer's premises will no doubt be easily arranged to meet all requirements and prevent accidents; it would, however, have been advisable to have made the limit between them 3 feet instead of 3 inches. This would have prevented any accidental or wilful short-circuiting with short bits of wire or domestic articles made from metal.

We drew attention in our last issue to the question of the minimum insulation per mile of conductors allowed in these Provisional Orders. Imagine *charging mains* with an insulation of 20 megohms per mile, under the influence of a charging current of 4,000 volts electromotive force. Submarine cables, working with about 40 volts, have in many instances an insulation exceeding the figure above (fortunately the lowest, be it remembered) by 20 or 30 times.

The regulations for consumers to observe in respect of electric lines *within* houses or buildings are much on the same lines as those proposed by Mr. Heaphy, C.E., for the guidance of the Phœnix Fire Office, and on which we made some comments at the time.

Returning for a while to the "unit" adopted by Mr. Moulton, and the prices to be charged per unit, it does not appear that the immediate development of electric lighting companies will receive any material benefit if the prices stated are to give any idea of the future rates. Take the case of a building wanting 1,500 Edison lamps. It would require 1,000 ampères at 100 volts, or 100 "units" per hour at 9d. per unit = 75s. per hour. Now

$$\frac{75}{1{,}500} = 0{\cdot}6\text{d. per "A" Edison,}$$

or 10 lamps for 6d. per hour. The horse-power accounted for in the lamps would be, say, 150 H.P. indicated, and if gas-engines were employed on the building, the cost would be 150 × 1d. = 12s. 6d. per hour, or

$$\frac{12\text{s. } 6\text{d.}}{1{,}500} = 0{\cdot}1\text{d.,}$$

or 10 lamps per hour for one penny. A company having to employ long leads, with their attendant cost and leakage, cannot be expected to compete in working cost with a local installation of considerable magnitude. The little saving which would be effected in the production of engine-power would be more than swallowed up in the power wasted in the leads.

Take 500 yards as a mean distance from the dynamo. This represents (supposing Mr. Moulton's minimum section is adopted) 1,000 yards of half a square inch of copper for 1,000 ampéres, with an expenditure of 80 H. P. in the leading wire alone, or enough to keep 800 Edison lamps going on the spot. We must say, however, that, all things considered, the regulations we have referred to—allowing for a little fogginess in the wording, which might lead to confusion—are well drawn up.

It is not necessary to bring before our readers the provisions made as to breaking up private streets and interference with railways and tramways. We next arrive at—

PENALTIES IN CASE OF DEFAULT BY THE UNDERTAKERS IN LAYING DOWN AND WORKING MAINS.

In case the undertakers shall neglect or refuse to lay down the mains, or perform the obligations specified in this Order or in Schedule A hereto, in respect of any of the matters set forth in *Schedule A*, within the time limited in that behalf, the Board of Trade may, in their discretion, *cancel this Order*, or may permit it to remain in force upon such terms as they shall think fit.

In case the undertakers shall neglect or refuse to lay down the mains or perform the obligations specified in this Order, or in *Schedule B hereto*, in respect of *any section of Schedule B* within the time limited in that behalf, the Board of Trade may, at their discretion, *remove such section from the area of supply*, or permit it to remain therein on such terms as they shall think fit.

The Board of Trade shall not exercise the powers contained in the preceding sections of cancelling this Order, or of removing any section of Schedule B from the area of supply, until after they have given to the undertakers three months' notice of their having made default as aforesaid, and have also given to the undertakers an opportunity of showing grounds why such power should not be exercised.

In case the Board of Trade shall, by reason of any default as aforesaid on the part of the undertakers, elect unconditionally to cancel this Order, or to remove any section of Schedule B therefrom, or may be willing to permit the same to remain in force, or such section to remain within the area of supply only upon terms which the undertakers refuse to accept, then (save as is herein otherwise provided) this Order shall be cancelled either wholly or with respect to the area comprised in such section, as the case may be, and thereupon *all the powers, duties, and liabilities of the undertakers with regard to the area of supply, or to the area comprised in such section*, as the case may be, *shall cease and be determined*, but the undertakers shall not be subject to *any other penalty* in respect of their default in the above behalf, save such as is set forth in this section.

The Board of Trade may at any time, *at the request or with the consent of the undertakers, cancel this Order or remove any district from the area of supply*, either unconditionally or on such terms as they shall think fit, and thereupon (save as is otherwise provided in the terms aforesaid or in this Order) all the powers, duties, and liabilities of the undertakers with regard to the area of supply, or such district thereof, as the case may be, shall cease and be determined.

In cases where any streets or parts of streets are common to more than one section of Schedule B, the powers, duties, and liabilities of the undertakers shall not cease as aforesaid with regard to such streets and parts of streets by reason of *some only* of the areas in which such streets or parts of streets are contained being removed from the area of supply.

Nothing herein contained shall take away the powers of the undertakers over any portion of the area otherwise than so far as relates to the supply of electricity within such part, but the undertakers shall (save with their consent, or in case of the cancellation of this Order) retain all their powers throughout the area of supply for the purpose of laying down, maintaining, or working, charging, or other mains used solely for and in connection with their supply to other portions of the area.

In case any electric lines or works belonging to the undertakers are situate in any area or district removed by the Board of Trade under the provisions of this Order from the area of supply, the undertakers shall retain all their powers over such area or district, so far as the same shall be necessary for the purpose of maintaining, taking up, or removing such electric lines or works, and may exercise the same at any time as they shall think fit.

In case this Order is cancelled under the provisions of the foregoing sections, and the undertakers have not removed their lines and works therefrom, or in case any of the lines and works belonging to the undertakers shall be situate within an area or district removed from the area of supply under the provisions of the aforesaid sections, the Board of Trade may, on granting any licence or Provisional Order to any local authority, company, or person over the whole or any part of the area of supply of this Order, or the area comprised in such area or district, as the case may be, make it a term of such licence or Provisional Order that such local authority, company, or person shall purchase and take over such portion of the said lines and works as is situate within the proposed area of supply (or so much thereof as the undertakers are willing to sell) at a price to be agreed upon, or, in case of difference, to be settled by arbitration. And in case such local authority, company, or person shall not, before applying for the said licence or Provisional Order, give his consent in writing to the undertakers to purchase and take over such portion of such lines and works as aforesaid, the undertakers shall be deemed to be persons affected by the granting of the said licence or Provisional Order, and shall be entitled to notice of the application for the same, and, if they shall so desire, to be heard in opposition thereto.

In the case of these penalties we do not see how we can add much to that which is already so well explained. It is apparent at once that provisions as to streets common to *different* areas is a very important matter. It is also necessary that power should be granted to allow a company to run feeding mains through a district, although the said company does not supply such district. Provision is made for future undertakers to take possession of the mains in a withdrawn area, but this is not compulsory.

The remainder of the *Order* consists of several sections regulating the assignment or transfer of the undertakers' installations and liability to any other local authority, company, or person. The consent of the Board of Trade will be necessary for every transfer, and this, it is hoped, will have the effect of avoiding traffic in concessions.

In case any local authority shall, under the provisions of Section 27 of "The Electric Lighting Act, 1882," require the undertakers to sell to them their undertaking, or any portion thereof as therein referred to, the position of the undertakers and of such local authority shall, after the completion of such sale, be in all respects the same as if such transfer had taken place under the provisions of the sections of the "Provisional Order," as the case may be.

The Section 27 referred to is as follows :—

Where any undertakers are authorised by a Provisional Order or special Act to supply electricity within any area, any local authority within whose jurisdiction such area or any part thereof is situated may, within six months after the expiration of a period of twenty-one years, or such shorter period as is specified in that behalf in the application for the Provisional Order or in the special Act, from the date of the passing of the Act confirming such Provisional Order, or of such special Act, and within six months after the expiration of every subsequent period of seven years, or such shorter period as is specified in that behalf in the application for the Provisional Order or in the special Act, by notice in writing, require such undertakers to sell, and thereupon such undertakers shall sell to them their undertaking, or so much of the same as is within such jurisdiction, upon terms of paying the then value of all lands, buildings, works, materials, and plant of such undertakers suitable to and used by them for the purposes of their undertaking within such jurisdiction, such value to be in case of difference determined by arbitration: Provided that the value of such lands, buildings, works, materials, and plant shall be deemed to be their fair market value at the time of the purchase, due regard being had to the nature and then condition of such buildings, works, materials, and plant, and to the state of repair thereof, and the suitability of the same to the purposes of the undertaking, and, where a part only of the undertaking is purchased, to any loss occasioned by severance; but without any addition in respect of compulsory purchase or of goodwill or of any profits which may or might have been or be made from the undertaking, or of any similar considerations. The Board of Trade may determine any other questions which may arise in relation to such purchase, and may fix the date from which such purchase is to take effect, and from and after the date so fixed, or such other date as may be agreed upon between the parties, all lands, buildings, works, materials, and plant so purchased as aforesaid shall vest in the local authority which has made the purchase, freed from any debts, mortgages, or, similar obligations of such undertakers or attaching to the undertaking, and the powers of such undertakers in relation to the supply of electricity under this Act or such Provisional Order or special Act as aforesaid, within such area or part thereof as aforesaid, shall absolutely cease and determine, and shall vest in the local authority aforesaid.

The duration of a Provisional Order, unless otherwise stated, remains in force with regard to area of supply, &c., from the date of its confirmation *till such time* as the local authorities shall purchase the undertaking, either wholly or so far as it relates to the supply within its jurisdiction, as the case may be.

The Board of Trade shall have power at any time, if it shall think fit, to relieve the undertakers from the performance of any of the regulations contained in the "Provisional Order," or any other regulations subsequently made by the Board of Trade with reference to the nature and mode of supply and the conditions to be observed in respect thereto, or may, with the consent of the undertakers, vary the same in any manner, or make fresh regulations for the same or like purposes, and such regulations so made shall have the same force and efficiency as if they had been included in the Order.

Nothing in the Order shall be deemed to interfere in any way with the power of the Board of Trade to make regulations for public safety, &c.

The Telegraph Clerks' Agitation.—After a considerable interval of quiescence the agitation in the ranks of the telegraph clerks for increased remuneration and the removal of certain grievances is daily increasing. Although little or no active action followed the promulgation of Mr. Fawcett's scheme of revision in 1881, yet the feeling of discontent which previously prevailed in the service was only partially allayed. Evidence of the discontent which still exists amongst the clerks is found in the fact that within a few weeks largely-attended meetings have been held in Edinburgh, Liverpool, Southampton, Exeter, Belfast, Newcastle, &c., where resolutions embodying their grievances were unanimously passed.

KNUDSON'S TYPE-PRINTING TELEGRAPH.

IN the United States of America, where competition is so keen, mechanical ingenuity must be taxed to the utmost in order that new enterprises may be started which are unfettered by existing patents. The great success which has attended the use of type-printing telegraph instruments (so much used for transmitting stock prices) has been very largely due to the employment of a zero adjuster. This adjuster insures the synchronism of the various instruments placed on one line, by periodically setting the type-wheels to zero, so that any accidental skip becomes almost immediately rectified. This zero adjustment, upon which so much depends, is the subject of several patents in the United States, and as these patents are owned by one or two companies it was a very difficult matter to design any arrangement which should enable synchronism to be obtained without infringing existing rights. Mr. A. A. Knudson, of New York, however, tackled the question, and has completely succeeded in producing a type-printer, which, we understand, is quite novel. In endeavouring to effect a particular object, Mr. Knudson has produced an apparatus which contains advantages which were not contemplated at first by the inventor, but which are nevertheless extremely useful.

The principal features of the printing instrument are the rapidity of its action, which is from 120 to 130 revolutions per minute, and, as we have stated, the method of bringing the instruments into unison; this is effected automatically by a clock attached to each instrument, and is carried out independently of the transmitting station. Mr. Knudson's original intention was to employ clock mechanism simply for the purpose of actuating a unison movement, but it then occurred to him that the utility of the new instrument would be considerably increased if an actual clock were employed, which, by means of a very simple additional mechanical movement, could be synchronised from the transmitting station, so the subscribers would have not only stock quotations printed, but would also have correct time furnished them.

The general appearance of the complete instrument is shown by fig. 1.

Generally speaking the action of the apparatus is as follows:—

The time piece at the transmitting station, by means of a scape wheel and anchor, works a reciprocating commutator which transmits along the line wire alternately positive and negative electrical currents, and these currents at each of the receiving stations excite electro-magnets and cause a polarised armature to reciprocate, and this by an anchor and scape wheel movement gives step by step rotation to a type wheel, which is thus moved synchronously with the scape wheel of the reciprocating commutator of the transmitter. This scape wheel by its rotation carries a rotating arm round a dial, around which are arranged a number of keys each for a particular letter or symbol. On depressing one of those keys this rotating arm meets the obstruction presented by the depression of the keys and is for a moment arrested, thus causing a prolongation of the duration of the current last sent out by the reciprocating commutator. This prolonged current at each receiver excites an electro-magnet, which, attracting its armature, causes a pad to press the travelling strip against the type of the type wheel at that moment presented towards it. Thus there is printed on the travelling strip the letter or symbol determined by the particular key depressed at the transmitter. At each receiving station at certain intervals an impulse is sent through an electro-magnet by the action of clock mechanism synchronised by the transmitting station; this impulse releases a clutch and presents a stop, so that such of the receiving

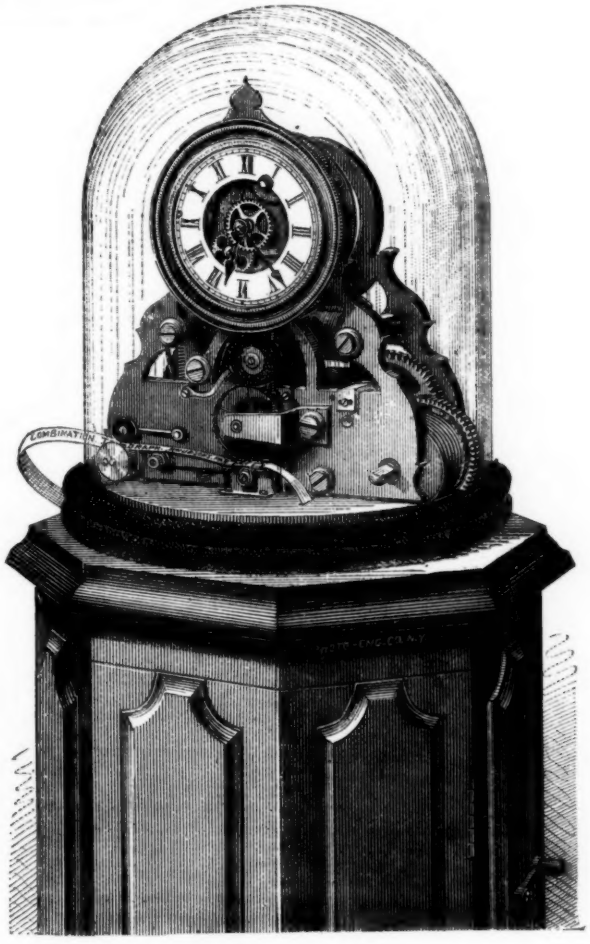


FIG. 1.

instruments as may happen to be out of adjustment are brought to their respective zero-points, and are thus restored to coincidence with the transmitter and with each other. This correcting action is arranged to take place only when the printing mechanism is for a time inactive. There is also a farther adjustment effected at longer intervals, as, for example, once every twelve hours, the minute hands of all the receiving time pieces being then, by similar means, brought to the same point.

The transmitting mechanism shown in fig. 2 consists essentially of a pole-changing device driven by a train of clockwork transmitting alternate positive and negative pulsations over the main line. This apparatus is controlled by a series of keys manipulated by the transmitting operator. The pole changing mechanism consists of two metallic contact plates, w and w^1, which are mounted upon a rectangular block, w^1, of non-conducting material, and are made to oscillate between two contact springs, w^3 and w^4. The spring, w^3, is connected directly with the earth by means of the wire, 1, and the spring, w^4, is connected with the line through the medium of the wire, 5, springs, s^1, s^2, and key, J^3. The contact piece, w^1, is connected with the positive pole of the main battery, o, by wire, 4, and the remaining contact piece, w, is connected with the negative pole of the same battery by the wire 2.

When the apparatus is in the position shown in fig. 2, the circuit may be traced from the earth through the wire 1 to the spring, w^3, thence by the contact piece, w, and wire 2 to the negative pole of the battery, o, and from the positive pole of the battery by wire, 4, to contact piece, w^1, and thence through the spring, w^4, and springs s^1, s^2 (the object of these springs will be explained further on), and key, J^3, to line. By the oscillation of the pole changing apparatus the poles of the main battery, o, are interchanged with respect to the line and earth wires, thus reversing the direction of the line current. The pole changer, w^1, is oscillated by means of a star wheel, v, which acts upon an anchor, v, each revolution of the wheel, v, causing a number of successive pulsations to be transmitted alternately of positive and negative polarity, which, taken together, are equal in number to twice the number of teeth. The rotation of the star wheel, v, is controlled by an arm, s, fixed to the wheel, A, which latter is geared to wheel, B, on the axle of which v is fixed.

The number of keys equals the number of the teeth and spaces taken together upon the star wheel, v, and this number may be varied in instruments designed for different classes of business. If the arm, s, is permitted to make one complete revolution, as many electric pulsations will be transmitted over the line as there are keys, and these will be alternately of positive and negative polarity. These pulsations serve to control the position of the type wheels of the receiving instruments in the manner which will be explained.

The printing of a particular letter at the receiving station after the type wheel has been brought into position is effected, as has been explained, by causing a prolongation of the duration of the current last sent out by the reciprocating commutator. The reversed currents pass through an electro-magnet with an unpolarised armature, which would be attracted when either a positive or a negative current flows for a prolonged period, but would be unaffected by the rapid reversals of short duration. The key, J^3, enables the current to be made and broken so that the printing electro-magnet can be caused to work several times in succession. This is useful in cases where one figure has to be repeated several times.

FIG. 2.

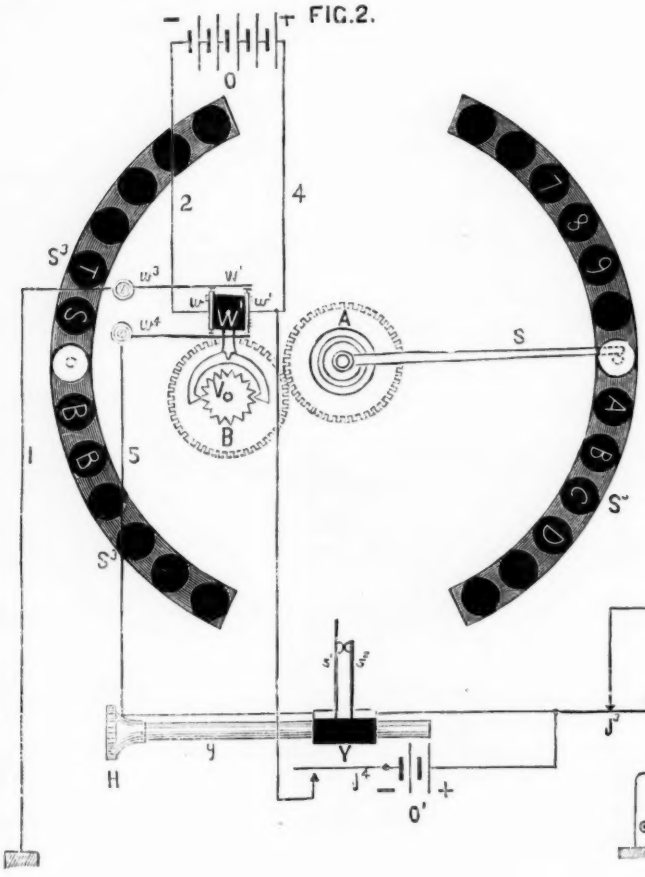


FIG 4.

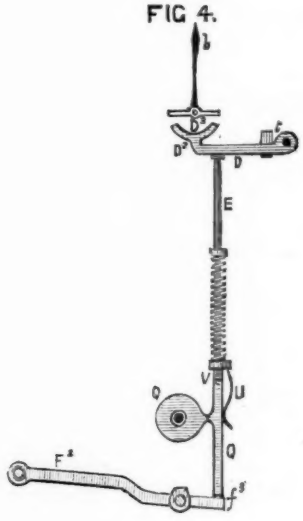
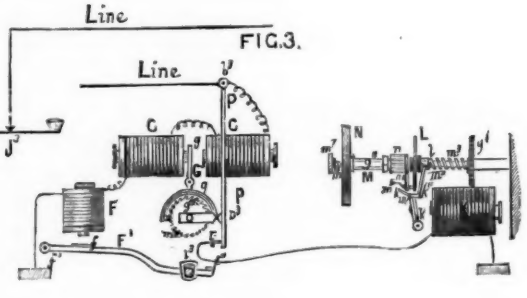


FIG.3.



The pulsation for adjusting the time mechanism is transmitted by the key, J^4, which when actuated, throws an additional section of battery, O^1 (of the same polarity as the main battery, o), into the same circuit, thus increasing the strength of current. The key, J^4, may be manipulated by hand, but it is preferred to connect it with a standard clock or regulator in such a manner that it is automatically actuated by the clock at a predetermined hour, minute, and second of time.

The apparatus at the receiving station consists of the printing mechanism, the unison mechanism, the time piece, and the device for adjusting or regulating the time piece.

Referring to the right hand portion of fig. 3, the mounting of the type wheel can be seen. The printing mechanism comprises a type wheel, N, which, together with a driving pinion, *n*, is mounted upon a sleeve or hollow axis, M, which turns upon a fixed shaft, g^3. The type wheel tends to revolve by the action of a train of wheel work moved by a weight or spring and driving a wheel which engages with the pinion, *n*; but the movements of the type wheel are controlled by means of an anchor escapement mechanism consisting of a scape wheel, g^2 (seen in the centre portion of fig. 3), and an anchor, *g*, attached to a vibrating armature, G^1, which is permanently polarised and vibrates to and fro, under the influence of alternate currents, between electro-magnets, G G, mounted so that their respective poles face each other. This arrangement of apparatus for producing or controlling the movement of a type wheel by alternating currents being well known requires no further explanation. The scape wheel, g^2, is normally coupled to the type wheel in the manner to be described.

To secure a more rapid vibration of the armature lever, G^1, a small coiled spring is inserted into a recess in the face of each of the cores of the electro-magnets, G, projecting beyond the end of the core.

F is an electro-magnet included in the circuit of the line wire, which acts upon the armature, *f*, affixed to the press lever, F^2, which turns upon a pin, f^1. A platten, f^3, is mounted upon the press lever beneath the type wheel, and a ribbon or tape of paper, f^2, is fed between the platten and the type wheel by means of the feed rollers which are caused to advance the proper distance after each impression by means of a scape wheel and pallets, affixed to and actuated by the press lever, F^2.

The unison mechanism whereby the position of the type wheel of the receiving instrument is brought into correspondence with the transmitter is constructed as follows :—

Upon the same shaft, g^3, which carries the escapement wheel, is mounted a clutch wheel, L, laterally movable along a feather, *l*, on the shaft. This clutch wheel is provided with a collar, m^2, having a groove into which fits a forked clutch, k^1, attached to the armature, *k*, of the unison electro-magnet, K. Near the periphery of the clutch wheel, L, is a series of holes adapted to receive a pin, *m*, mounted upon the end of an arm, m^1, projecting from the sleeve, M, of the type wheel, N. The clutch wheel, L, is normally pressed towards the arm, m^1, by means of a spring, m^3, and engages with the pin, *m*, thus locking the parts together, so that the type wheel, N, can revolve only in correspondence with the movement of the scape wheel, g^2. Whenever a current of electricity is sent through the unison magnet, K, the armature, *k*, carrying the clutch arm, k^1, is attracted, thus disengaging the wheel, L, from the pin, *m*. The type wheel and pin on being thus released from the scape wheel, g^2, will revolve by the action of the clockwork exerted through the pinion, *n*, in the direction of the arrow, until arrested at the zero point by reason of a stop, m^5, upon the arm, m^1, meeting a projection, k^4, from the armature, *k*, when that armature is attracted towards its magnet. Thus whenever an electrical current traverses the unison magnet, K, the type wheel is automatically brought to the zero point, and when this current is interrupted, the armature, *k*, is thrown back from the poles of the magnet by the pressure of the spring, m^3, against the collar, m^2, and the type wheel sleeve becomes again locked to the scape wheel by the pin, *m*, entering one of the holes in the periphery of the clutch wheel, L. A friction spring, m^6, is provided to press against the sleeve of the type wheel and the binding screw, m^7, at the end of the shaft, g^3, to prevent the recoil of the type wheel when suddenly arrested, or its too rapid movement.

The device for sending an electrical impulse at frequent intervals through the unison magnet, K, in order to correct the position of the type wheel, consists of a shunt or switch operated by the movement of the time piece, whereby the major portion of the current of the main line, which controls the type wheel, is shunted through the unison magnet (in case the instrument should not be at unison), whenever the escapement mechanism is inactive during a few seconds. The mechanism for this consists of an arm, P (see fig. 3), suspended from the axis, b^3, of the minute hand of the clock. The upper end of the arm, P, is loose upon the shaft, and is pressed against a shoulder thereon by means of a spring constituting a frictional connection. The motion of the minute hand causes the arm, P, when unobstructed, to be gradually moved in a direction corresponding with the motion of the hand, *b* (fig. 4), thus bringing the end of the lever in contact with the point, r^1. When the arm, P, is in its normal position, the circuit is formed through the electro-magnets, G and F. The movement of the shaft, b^3, causes the arm, P, to be gradually moved towards the contact, r^1, thus shunting the major portion of the current (the resistance of K being small compared with G and F) from the type wheel and printing magnets through the unison magnets and operating device in the manner before described. By the wiper, m^4, upon the sleeve, M, acting (when the type wheel reaches its zero point) on the incline of a tooth, p^3, at the lower extremity of the arm, P, the latter is thrown back and held back as long as the type wheel remains at its unison point, thus maintaining open the circuit through the contact point, r^1, and the unison magnet, K, until the type wheel is again operated. Whenever a momentary pause occurs in the operation of the escapement mechanism, and the type wheel is left in any position other than zero, the end of the spring attached to the lever, D, is brought against the contact point, *r*, by the time movement, thus operating the unison mechanism. The wiper, m^4, upon the sleeve which carries the type wheel is also adjustable by means of the screw, m^8. The end of the wiper, m^4, and the tooth, p^3, are preferably wedge shaped, and m^4 is so adjusted that it blocks p^3, only when the type wheel is exactly at the unison point.

The mechanism for correcting the time is as follows (fig. 4) :—An incline, *t*, is provided, so that when the lever, D^1, is raised it is also moved horizontally so as to bring its yoke, D^2, immediately under the correcting bar, D^3. The lower part of the rod, E, is hinged at V, and pressed by a spring, U, and has a wedge tooth projecting from it towards a cam, Q, fixed on thesleeve of the type-wheel. Usually the lower end of Q^1 is clear of the screw, f^3, on the press lever, F^2, but when the cam, Q, is turned to the position shown in fig. 4, pressing back Q^1, an upstroke of the lever, F^2, raises the rod, E, and the yoke, D^2, giving the correction required. The springs, s^1, s^2, seen in fig. 2, are fixed on a block of ebonite, Y, which is secured to an axle, *y*, having a finger knob, H, attached to it. If this knob is twisted round, the springs, s^1, s^2, are moved to a position (the normal one) in which the arm, S, is free to rotate without coming into contact with them. If, however, the springs are moved to the position shown in fig. 2, then the arm, s^1, will be arrested in its rotation by the projecting end of spring, s^1, and when it does so it presses s^1 away from contact with s^2. When the arm comes to rest against s^1 then the position of the reciprocating commutator will be that shown in the figure. Consequently, if J^4 be depressed the battery, O^1, will be brought into circuit with O, and the line and an increased current will flow, this increased current being required in order to overcome the extra work involved in moving the clock hands. When the transmitting station desires to correct the clocks, then at a short time before the hour he turns the knob, H, so as to bring the springs, s^1, s^2, into position, and depresses the finger-key opposite s^1, s^2, so that the arm, s^1, turns, and is arrested at the spring, s^1. Under these conditions the type-wheels will have revolved till the cam, Q^1, of each instrument comes to the position shown in fig. 4. Then after waiting for a few seconds for the standard clock to arrive at the exact hour, an electrical impulse, sent either by hand or automatically by the standard clock, causes the press lever, F, to make an upstroke, effecting the correction.

A company has been formed in New York for working Mr. Knudson's invention.

Distribution of the Electric Potential in Batteries.—By L. Malarasi.—The author calculates numerically the potential values in different parts of a battery for plates of different sizes, and proceeds from the well known proposition that when in a single element the surfaces of the plates are *m* and *n*, their potentials *x* and *y*, and the constant potential difference between both is 2 *a*, then

$$x - y = 2\,a,\; m\,a = -\,n\,y,$$

from which *x* and *y* are found.—*Wiedemann's Beiblätter.*

LECTURES ON ELECTRICAL SCIENCE.

THE first of a series of six lectures on the applications of electricity, entitled "The Progress of Telegraphy," was delivered on Thursday evening, February 15, by Mr. W. H. Preece, F.R.S., M. Inst. C.E., before the members of the Institution of Civil Engineers. The following is an abstract:

Telegraphy is the oldest practical application of electricity. It grew about the railway system, and was rendered a practical agent by the foresight of Robert Stephenson, I. K. Brunel, Joseph Locke, and G. P. Bidder, who were its godfathers in England. Electric currents are, as a rule, maintained for telegraphic purposes by the combustion of zinc, and in the innumerable forms of batteries in use the conversion of zinc into sulphate of zinc is the root of the transformation of energy into that form which was utilised as electric currents. There are three forms of battery in use in the British post-office telegraph system, and in the following numbers:—

Daniell	87,221 cells.
Leclanché	56,420 ,,
Bichromate	21,846 ,,

Every administration has its own adopted form, differing in design but based on one or other of these types. Magneto-electricity is employed for some forms of apparatus, and dynamo-machines are sometimes used to supplement batteries. The various terms employed—electromotive force, resistance, induction, and current—though measurable in definite units, have not yet become household words; but, being admitted into commercial, legal, and parliamentary lore, they will soon be as familiar as feet, gallons, or pounds.

Electric currents are conveyed from place to place either overground, underground, or submarine.

OVERGROUND.—Wooden poles preserved in creosote are employed in England, but iron poles are extensively used in the colonies. The conducting wire is almost universally of iron, but copper wire is much used through smoky places where iron is liable to rapid decay. Phosphor-bronze wire is under trial, and is a very promising material, as it possesses the conductivity of copper with the strength of iron. The improvements made in the quality of iron wire have been very great, and it conducts now fully 50 per cent. better than it did a few years ago. Electric tests have had a marvellous effect upon the production of pure metallic conductors; copper has improved in even greater ratio than iron; samples have been produced better even than the standard of purity. The insulators remain principally of porcelain, and their forms vary nearly with the number of individuals who use them; the only improvement of any value recently made is one which facilitates the very necessary process of cleaning.

UNDERGROUND.—Wires are almost invariably carried underground through towns. Copper wire, insulated with gutta-percha, encased in iron pipes, is the material used. There are 12,000 miles of underground wire in the United Kingdom. There is a great outcry for more underground work in England, owing to the destruction to open lines by gales and snow storms; but underground telegraphs, wire for wire, cost at present about four times as much as overground lines, and their capacity for the conveyance of messages is only one-fourth; so that overground are, commercially, sixteen times better than underground wires. To lay the whole of the Post-office system underground would mean an expenditure of about £20,000,000. Hence there is no desire to put wires underground except in towns. Besides snowstorms are few and far between, and their effects are much exaggerated. Of the numerous materials and compounds that have been used for insulating purposes, gutta-percha remains the oldest and the best for underground purposes. It, like all other materials used for telegraphy, has been improved vastly through the searching power that the current gives the engineer.

SUBMARINE.—The past ten years has seen the globe covered with a network of cables. Submarine telegraphs have become a solid property. They are laid with facility and recovered with certainty, even in the deepest oceans. Thanks to such expeditions as that of H.M.S. *Challenger*, the floor of the ocean is becoming more familiar than the surface of many continents. There are at present 80,000 miles of cable at work, and £30,000,000 have been embarked in their establishment. A fleet of twenty-nine ships is employed in laying, watching, and repairing the cables. The Atlantic is spanned by nine cables in working order. The type of cable used has been but very little varied from the first made and laid between Dover and Calais; but the character of the materials, the quality of the copper and the gutta-percha, the breaking strain of the homogeneous iron wire, which has reached 90 tons to the square inch, and the machinery for laying, have received such great advances, that the last cable across the Atlantic, laid by the Telegraph Construction and Maintenance Company, was done in twelve days without a hitch or stoppage.

Ideas are conveyed to the mind by electric signals, and, in telegraphy, these signals are produced at distant places by using two simple electrical effects. (1) That a magnetic needle tends to place itself at right-angles to a wire when an electric current passes through it; and, (2) that a piece of iron becomes a magnet when a current of electricity circulates around it. An innumerable quantity of tunes can be played on these two strings. Various companies were established at different times to work certain systems, but when the telegraphs were absorbed by the State, the fittest were selected to survive and their number consequently declined.

The A B C instrument is the simplest to read, for it indicates the letters of the alphabet, by causing a pointer to dwell opposite the desired letter. There are 4,398 in use. Its mechanism is, however, complicated and expensive, and it is being rapidly supplanted by the telephone. The needle instrument is the simplest in construction, but it requires training to work it. There are 3,791 in use in the Post-office, and 15,702 among different railway companies. As a railway instrument it is the simplest, cheapest, and most efficient ever devised. The Morse instrument, of which there are 1,330 in use in the Post-office, records its letters in ink, in dots and dashes on paper tape, and like the needle and A B C appeals to the consciousness through the eye; it also indicates the letters of the alphabet by sound, and thus utilises the organ of hearing. Sound-reading is gaining ground in England with great rapidity. There are now 2,000 sounders in use; in 1869 there were none. In America scarcely any other instrument is used. On the Continent there is scarcely one.

Acoustic reading attains great perfection in Bright's bell instrument, where beats of different sound replace the dot and dash of the Morse alphabet. Sound reading is more rapid and more accurate than any system of visual signals or permanent record. In fact, no record is kept in England, for the paper tape is now destroyed as soon as it has been read. Errors are of course inherent to all systems of telegraphy. A telegraphist cannot see what he writes, or hear what he says, and who is there that does not make mistakes, whose eye follows his pen, and whose ear takes in his own words? The Hughes Type-Instrument, which prints messages in bold roman characters, is much used on the Continent, it is in fact recognised as the international instrument, but it has had to give way in England to a more rapid system of telegraphy. It is, however, solely used for the Continental circuits by the Submarine Telegraph Company. All long cables are worked by Sir William Thomson's beautiful Siphon-Recorder.

In ordinary working only one message can be sent in one direction at one time; but by a simple and ingenious contrivance, by which the neutrality of opposite currents is utilised to convey signals, duplex telegraphy is rendered possible, so that two messages can be sent on the same wire at the same time; and, by a still further improvement, where currents of different strength are utilised, four messages are sent on one wire—two simultaneously in opposite directions—at the same time. There are in England 319 duplex and 13 quadruplex circuits at work.

The acme of efficiency in telegraphy is attained in the automatic system, in which manual labour is supplanted by mechanism in transmitting the messages. There are 71 circuits worked by these instruments, and 224 instruments in use, and a speed of working of 200 words per minute is easily maintained upon them. When the hand alone is used, from 30 to 40 words per minute is the maximum rate attained, but by automatic means the limit is scarcely known. Since this system can be duplexed, and in many cases is so, 400 words per minute on one wire are easily sent. By the use of high-speed repeaters, the length of circuit for automatic working is scarcely limited; it would be easy to send 100 words per minute to India.

The growth of business since the telegraphs have been acquired an the State is enormous: 126,000 messages per week have grown to an average of 603,000; but the mileage of wire has not increased in anything like the same proportion, the excess of traffic having been provided for by the great improvements made in the working capacity of the apparatus. In 1873 the average number of messages per mile of wire was 147; it is now 256. It is in press work that the greatest increase has taken place; 5,000 words per day at the time of the companies have grown to 934,154 words per day now. 340,966,344 words of press matter were delivered in the year ending March 31, 1882.

The development of railways has necessitated a corresponding increase in the telegraphs required to insure the safety of the travelling public, and while 27,000 miles of wire in England, Scotland, and Wales were used for that purpose in 1869, at the end of December, 1882, the total had increased to 69,000 miles, equipped with 15,702 instruments, against 4,423 in 1869.

The growth of business is equally discernible in the great cable companies. In 1871 the number of messages dealt with by the Eastern Telegraph Company was 186,000; in 1881 it was 720,000. This growth is equally striking in all civilised countries, and even in Japan 2,223,214 messages were despatched, of which 98 per cent. were in the native tongue. The mode of transacting the trade of the world has been revolutionised, and while wars have been rendered less possible, their conduct has been expedited and their penalties alleviated.

The second lecture of the series will be on "Telephones," by Sir Frederick Bramwell, F.R.S., V.P. Inst. C.E. This is to be delivered on March 1.

Rumoured Consolidation of the Western Union and Mutual Union.—For some time, says the *Electrical World* of New York, there have been reports that the troubles between the Western Union and Mutual Union Telegraph Companies were approaching an adjustment. The statement, said to have emanated from Mr. Jay-Gould, was made that the Western Union had offered to lease the Mutual Union lines for a term of 100 years and pay 6 per cent. interest on the 5,000,000 dols. of bonds and 1½ per cent. on its 10,000,000 dols. of stock. Beyond Mr. Gould's rumoured proposition it could not be ascertained that any basis for a settlement had been formally suggested. Mr. John G. Moore, the president of the Mutual Union, said there had been negotiations to end the litigation, but no official action had been taken.

ON ELECTRIC LIGHTING FOR WORKSHOPS AND LARGE SPACES.

By Mr. ANDREW JAMIESON, A.M. Inst. C.E., F.R.S.E., &c., Principal, College of Science and Arts, Glasgow.*

THE subject of electric lighting has lately received a large amount of attention from many of our most scientific and practical men, public interest has been greatly awakened regarding it, and the patent office has been inundated with specifications and applications all more or less proposing to give us perfect electric lighting. Numerous companies have been formed, with large subscribed and still larger nominal capital, with a view, in some instances only to sell patents and patent-rights; in others, with the more honourable and honest purpose of making and installing their appliances—each one claiming its speciality or system to be the best either as a whole or in some particular feature.

Our leading scientific and engineering journals have, of late, been full of descriptions of this or that dynamo and electric lamp, or of some special installation or electrical exhibition, using terms and electrical phraseology which, to some, must have appeared new and difficult to understand.

There is at the present moment scarcely a town in the kingdom which has not had a trial of the electric light, and whose authorities are not worrying themselves as to whether they shall or shall not seek for a "Provisional Order," and thus have the right, under the Board of Trade, of supplying their inhabitants with "the light of the future."

In this paper I do not propose to describe anything very new or startling; neither do I wish to advocate one particular system in preference to another (for I have no pecuniary interest in any of them), but rather to lay before you a short description of how the various and necessary appliances are constructed and applied in order to produce electric lighting suitable for workshops and large spaces, and to make clear a few of the most common of the electrical terms, as well as to compare the efficiency and cost of electric lighting with that of gas lighting.

PRACTICAL ELECTRICAL UNITS OF MEASUREMENT.

In the first place, I shall define the several units used in measuring currents in connection with electric lighting. The practical electrical units of measurements now universally adopted by all electricians, were finally determined upon at the International Congress of Electricians, Paris, 1881, and British Association, 1882.

Since electricity, by whatever means generated, is the result of the expenditure of energy (mechanical energy as a rule, in the case of electric lighting), and, as the measurement of energy involves *space*, *matter*, and *time*, the three fundamental units adopted were the centimetre for length, gramme for mass, and second for time, which is termed the centimetre, gramme, second system, or shortly, the C.G.S. system; and upon these fundamental units all the practical electrical units of measurement are based.

ANALOGY BETWEEN WATER AND ELECTRICITY.

An electric current may, for all practical purposes, be considered analogous to a fluid, under conditions somewhat similar to those by which water flows along a pipe.

1.—*Electromotive force compared to head or pressure.*—The difference of level or pressure, due to gravity, between the top and bottom of the water pipe (fig. 1); in other words, the "*head*," causes the flow of water along the pipe, while the difference of potential or electrical pressure between the ends of the copper wire (fig. 2), in other words, the *electromotive force*, as it is termed, causes the flow of electricity along the wire. The potential, or pressure, in both cases, determines the power of doing work, as illustrated by the water now flowing from the elevated tank along the pipe and driving the small water-wheel on the table, and by the voltaic battery generating electricity now flowing along the copper wire and driving the small dynamo-electric engine, also on the table, and usefully employed pumping water.

2.—*Electric resistance compared to friction*:—The *friction* generated between the running water and the inside of the pipe offers a certain amount of resistance to the flow of the water, and may be considered so far analogous to the *resistance* offered by the metallic conductor to the flow of the electricity along it.

3.—*Strength of electric current compared to flow of water.*—The flow of the water along the water pipe, and the strength of the electric current along the conducting wire, are in each case determined by the pressure overcoming the resistance.

4.—*The quantity of electricity compared to the volume of discharge or volume of flow of the water* is in each case determined by the current passed in a second.

5.—*Power.*—In order to estimate the power of the current developed in each case, we have simply to multiply the total pressure by the current passed per second.

EXACT DEFINITIONS OF PRACTICAL ELECTRICAL UNITS.

1.—*Electromotive force* = (E).—*The Volt* is equal to 10^8 C.G.S.* units of electromotive force, or about 8 per cent. less than the E.M.F. of a standard Daniell's cell. Electromotive force is equivalent to the difference of potential between two points.

2.—*Resistance* = (R).—*The Ohm* is equal to 10^9 C.G.S.* units of resistance. It is equal to the resistance of a column of pure mercury 1·0624 metres long, of a square millimetre section, at the temperature of zero centigrade; or roughly, the resistance offered by 240 feet of pure copper wire, No. 18, B.W.G. ($\frac{1}{20}$ inch, or 1·274 millimetres in diameter), at 60° Fahr., is equal to one ohm. Resistance of copper increases with the temperature by about 0·21 per cent. per degree Fahr. Resistance varies directly as the length, and inversely as the sectional area of the conductor.

3.—*Current* = (C).—*The Ampère* is equal to 10^{-1} C.G.S.* units of current. It is the current produced by a volt through an ohm.

$$\text{Ohm's law...Current} = \frac{\text{Electromotive force}}{\text{Resistance}}, \text{ or } C = \frac{E}{R}.$$

4.—*Quantity* = (Q).—*The Coulomb* is equal to 10^{-1} C.G.S.* units of quantity. It is the quantity of electricity given by an ampère in a second.

5.—*Power* = (P).—*The Watt* is equal to 10^7 C.G.S.* units of power. It is the power conveyed by a current of an ampère through a conductor whose ends differ in potential by a volt; or, in other words, the rate of doing work when an ampère passes through an ohm, and is equal to 10^7 ergs ($\frac{1}{746}$ of a horse-power).

$$\therefore E \times C = \text{watts, and } \frac{E \times C}{746} = \text{horse-power} = 33{,}000 \text{ ft. lbs. per minute.}$$

MOTIVE-POWER FOR DRIVING DYNAMOS.

Before describing the dynamo, or generator of electricity, I shall just say a word or two about the most suitable machines for producing the mechanical power which has to be converted into electrical energy by the former.

First, we have the steam-engine; second, the gas-engine; third, the water-wheel or turbine; fourth, the wind mill; and a fifth has been proposed, but not yet put into practice, viz., a machine for utilising the rise and fall of the tides.

Of all these, the most suitable and, at the present time, the most popular, is the steam-engine. Whatever kind of machine is adopted, it is absolutely necessary that so long as the power developed by it is applied to driving a dynamo, in direct circuit with the electric lamps, the motion should be as uniform as possible, in order to insure a steady current or electromotive force. For this purpose, in the case of the steam-engine, it should be fitted with a sensitive and efficient governor, and it should be capable of easily furnishing the necessary power without in any way overstraining any of its parts, and be constructed of the very best materials in the

* Read before the Institution of Engineers and Shipbuilders of Scotland, January 23rd, 1883.

* Electro-magnetic system. For the other units see Rankine's Rules and Tables, sixth edition.

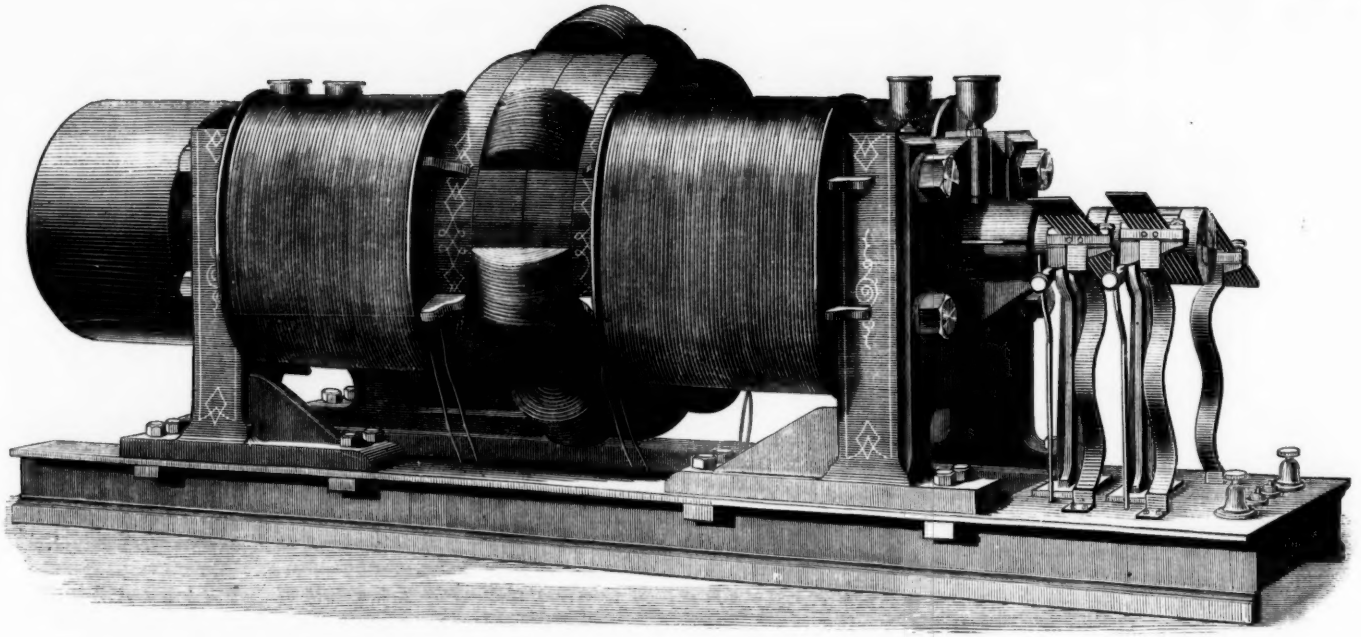


FIG. 4.

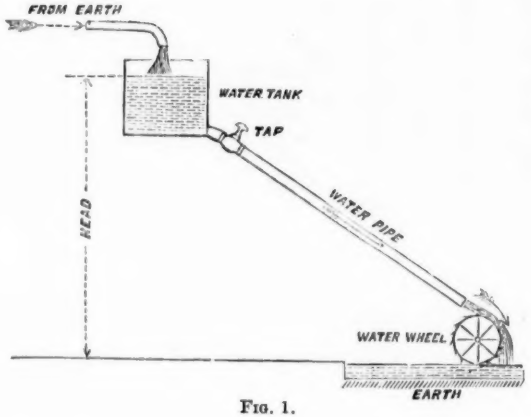


FIG. 1.

The armature, A, A, and commutator, C, C, are shown at right angles to their natural positions for simplicity of explanation.

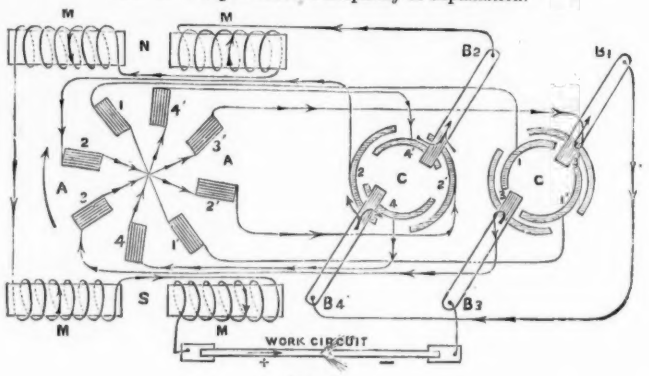


FIG. 6.

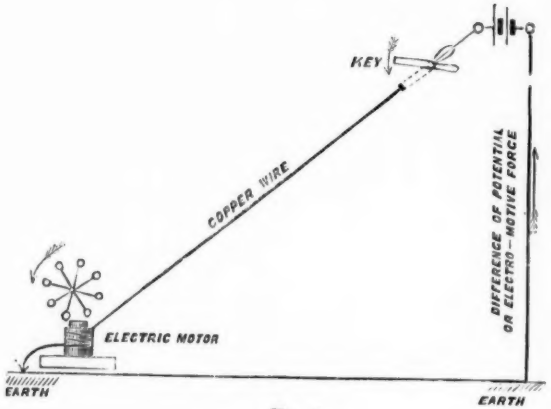


FIG. 2.

best possible manner, so as to minimise the chance of a break-down. In the case of workshops, where there is an ample reserve of power developed by the shop engine, and the demand upon its energy does not alter very rapidly, it has been found suitable, in many instances, to drive the dynamo by means of the same; but this should not be attempted before carefully testing and considering well the capabilities of the engine.

The armature, A, is shown revolving at right angles to its natural position for simplicity of explanation.

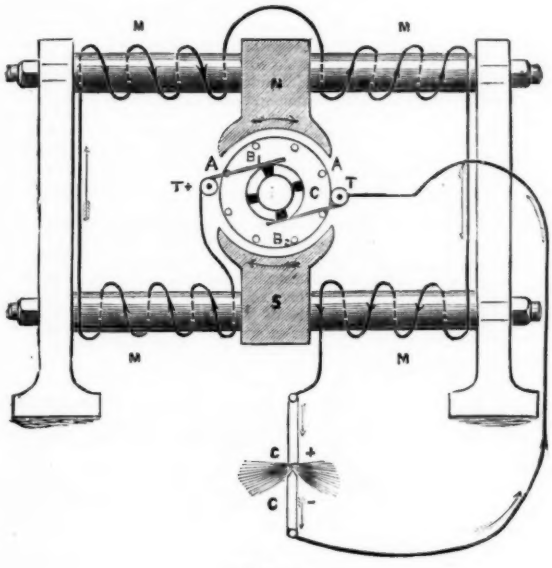


FIG. 3.

Diagram of "Gramme" machine and connections.

The demand for electric lighting has necessitated a special class of engines for this work, and several well-known makers, notably Messrs. Marshall and Sons, and Messrs. Tangye Brothers, have devoted much attention to this subject. The driving connection between the engine and the dynamo is usually carried out by means of belting either direct from the fly wheel to the dynamo pulley, or by the intervention of a counter shaft.

It is only in the case of steamships, or where the space is limited, that the motion is communicated direct from the engine shaft to the dynamo, without the intervention of belting or gearing, and in such cases the engine must be run at a very high speed, or the dynamo so arranged as to work at an abnormally slow rate.*

Gas-engines are becoming more popular, and, by using a fly wheel on the dynamo shaft, with long slack belting to counteract the effect of their somewhat irregular motion, they are, in many instances, found very serviceable. Sir William Thomson has adopted a 6 horse-power Clerk's gas-engine at his laboratory, and Professor Blyth, at Anderson's College, an 8 horse-power one, apparently with good effect.

Water power has, as yet, been but sparingly employed, either through the intervention of water-wheels or turbines, probably from the fact that where the electric light is in greatest demand, water is not available; but there cannot be much doubt that, as the mill-owners whose works are supplied with plenty of water power begin to realise the advantages of this form of artificial light, water power will be greatly taken advantage of; and, from the ease with which it can be manipulated, it will be found quite as efficient as the best steam-engine, and certainly prove less costly.

Windmills and tidal machines are out of the question until that much-required desideratum, viz., the storage of electricity, can be economically effected.

DYNAMOS.

We now come to the dynamo, or producer of electricity, for feeding electric lamps.

Gramme dynamo.—To illustrate the general principle upon which this machine depends, your attention is called to fig. 3 and

INDEX OF PARTS.

S,	spindle carrying
A, A,	armature revolving between
N, S,	the north and south seeking poles of
M, M, M, M,	the electro-magnets. Around the iron cores of which, the wire from
T +	the + terminal of armature is wound as shown until it joins
C +	the carbon (+) or upper carbon of the arc lamp,
T,	the (—) terminal of armature being joined to
C —	the carbon (—), or lower carbon, of the arc lamp;
B_1, B_2	the brushes which collect the currents from
C,	the commutator, whose metallic parts are soldered to the nearest points of the coil of wire which forms the armature.

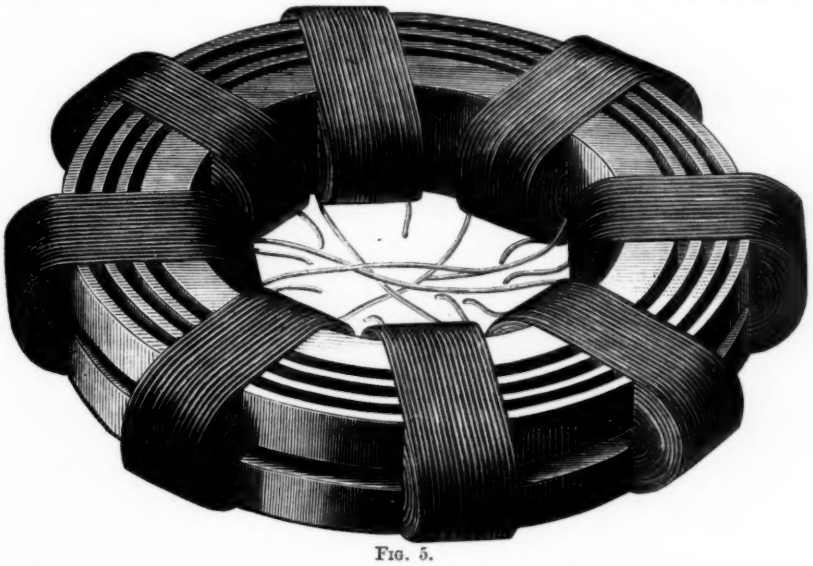


FIG. 5.

There being always some residual magnetism in the pole pieces, N, S, and iron cores (after having once been magnetised), there exists a weak magnetic field between N

* As examples, we have the electric lighting on board the s.s. *Servia* by means of Swan lamps, where a Brotherhood three-cylinder engine, running at about 600 revolutions per minute, drives direct Siemens' exciter and alternate current dynamos; and the s.s. *Waihora*, just completed this week by Messrs. Denny, of Dumbarton, and fitted throughout upon Edison's system with 150 incandescent lamps, the dynamo being driven direct by a three-cylinder Brotherhood engine running at 500 revolutions per minute.

and S, and the lines of force pass through the armature, A, A, and its iron core, at right angles to the copper wire coiled round the same. Consequently, upon revolving the armature, A, A, its copper wire coil cuts these lines of force at right angles; a current is thus generated which is led off by the brushes in the direction shown by the arrows, still further increasing the magnetism of N and S, which, in turn, reacts on the armature core and coil until such a speed is attained that the electricity generated and flowing round M, M, M, M, completely saturates the iron cores and pole-pieces with magnetism. Any further increase in speed will cause unnecessary heating of the electro-magnet coils, owing to the current passing through them being in excess of that required to saturate the cores and poles.*

Brush dynamo, see fig. 4.—In the Brush machine the armature coils are wound upon an annular soft iron core (see figs. 4 and 5) as shown, and being revolved in a most advantageous manner, as close as practicable to the poles of the electro-magnets, great electrical energy (E × C) is obtained for a given speed. A reduction of the total resistance of the armature coils is caused by cutting out of circuit two of them when in the least effective position. The commutator and its brushes are so placed upon the shaft, outside of the main bearings, that they can be easily got at for cleaning and repair, and are therefore more easily kept in good working order. The capability of generating currents of high electromotive force, with a mean current strength of 10 ampères, so that any number of lamps, from 1 to 40, may be worked in one circuit in series, and the comparatively low speed at which the larger machines are driven (viz., 750 revolutions per minute for a 16-light machine) are all advantages claimed for this machine.

The Brush system has been constantly at work at the well-known engineering works of Messrs Mirrlees & Watson, and Messrs. Robert Napier & Sons for two years, where I find it has given great satisfaction, and it has lately been installed in Aberdeen and Dundee for their street lighting.

The connections of the Brush machine have hitherto been considered rather a mystery, often misconstrued from diagrams hitherto given, but I hope the theoretical diagram (see fig. 6), along with the following description, will make them clear to you. The armature coils, A, A, and commutator parts, C, C, are shown in the diagram at right angles to their position in the machine, with a view to facilitate tracing the connections. The opposite coils, whose inner ends are connected together, are numbered (1—1′), (2—2′), (3—3′), and (4—4′), while the opposite plates on the commutator to which the coils are respectively connected are similarly marked. Starting from armature coils (3—3′) and following the direction of the arrows which indicate direction of current, we come to commutator plate 3′ to brush B_1, then to brush B_4, where the current splits at plates 2 and 4; by 2 to coils (2—2′) to plate 2′ and by 4 to coils (4—4′) to plate 4′ where brush B_2 unites the currents again and leads them to the electro-magnets, M, M, M, M, through which it passes to the (+) carbon or work circuit across the arc where light is produced, and along the (—) carbon to brush B_3, commutator plate 3, back to armature coils (3—3′) thus completing the circuit. It will be seen that each pair of coils as they come into the position (1—1′) are cut out of circuit, thus reducing the armature resistance mentioned before.

(*To be continued.*)

On the Heat developed by a Current during its Variable State.—E. Bazzi.—The author has measured the sum by the total thermic effect of the primary current of an inductorium by means of Felici's interrupter. The intensities calculated according to the formula of Helmholtz, and the production of heat, calculated according to Joule's formula, agree with experience, so that Joule's law holds good also for the variable period of induced currents. Blaserna points out that oscillatory discharges may seriously affect the simplicity of these phenomena when the intensity is measured in single moments as a function of the time.—*Wiedemann's Beiblätter.*

* An A Gramme machine belonging to the College of Science and Arts, with its different parts specially painted to illustrate (fig. 3) and make apparent their uses, was exhibited and explained to the meeting. The different places in Glasgow where the Gramme machine can be seen daily at work, were also mentioned.

ELECTRIC LIGHTING AND LOCOMOTION.

(Lecture I., delivered by Professor AYRTON, F.R.S., at the London Institution, February 22, 1883.)

FORTY-THREE years ago it was practically shown by Jacobi, on the river Neva, that locomotion by the aid of electricity was possible. No experiment, then, merely to prove this fact is needed at the present day. Nevertheless, both experiments and calculations are still necessary to convince the world that electric locomotion is not only possible but also commercially practicable. That electric transmission of power possesses great advantages—arising, first, from the small weight of the electro-motor per horse-power developed by it; secondly, from the fact that large amounts of power can be transmitted through quite thin flexible wires—must also have struck any one who has ever seen a powerful machine driven by electricity. Its disadvantages are generally summed up in the single sentence that it is too expensive. But people, as a rule, do not trouble themselves to inquire whether it is really more expensive than other modes of transmitting power, and whether, if this be the case, it arises from some inherent defect in the principle itself, or merely from some removable imperfection in the machinery hitherto employed for the purpose.

At the present day the public may be divided into two classes—the one who thinks that electric locomotion and transmission of power will act as a sort of philosopher's stone, and solve all difficulties: the other, that it is a new-fangled notion, and carefully to be shunned. The first class implores to be allowed to buy shares in any company that can in any sort of way have the word "electric" tacked on to its title, while the other buttons up its pockets at the mention of the word electricity and busies itself with what it terms "something useful and practical." And unfortunately the repeated failures of the sanguine members of the first class to reach the El Dorado they have imagined to themselves only strengthens the belief of the more cautious members of the second class in their shrewdness and in the wise decision they fancy they have arrived at, that electricity is a mere will-o'-the-wisp.

But you, I am sure, will not have that opinion when you have seen to-night what can be done by electricity. I turn on this electric tap, and at once this fan commences to revolve rapidly, and sends forth a rush of wind. That, perhaps you will say, could as well be done by a belt driven by a steam-engine; but I turn on another tap in the same supply wire, and at once the fan is lighted up by this electric lamp. That could not have been done merely by a steam-engine. Again, a third tap; this electric fire burns, and the water starts boiling in this glue-pot. [Experiment shown.] This thin flexible wire then furnishes a supply of electric power which can at will be used for producing motive-power, light or heat.

Now to produce this supply of electric power, we must first have a steam-engine, a gas-engine, a water-wheel or windmill to produce motion, and a dynamo machine to convert the mechanical energy into electric energy. These may be in the same room, or in another part of the building, or in another street, or away in the country; the electric power may be brought by a wire and used directly, or it may be stored in Faure-Sellon-Volckmar accumulators and used at some subsequent time, as I am doing now, thanks to the courtesy of the Electric Power Storage Company, indeed I may mention that in all my experiments I am using only stored electricity. And in this room, where we are utilising this supply of electric power, we must have an electro-motor if we want motion, an electric lamp if we want light, and an electric fire if we want heat. The transmission of power by electricity seems then very useful. Can it be made commercially remunerative?

As there are doubtless many in this hall who are deeply interested, either from scientific or from commercial reasons, in the answer to this question, and generally in the practical applications of electricity, it will be well to commence this lecture by considering, as shortly and as popularly as possible, what are the real difficulties besetting electric transmission of power, and what are the means electric engineers are proposing for surmounting them. Let us then attack the question together, not in the rosy, sanguine, humour of the promoters of electric bubble companies, nor with the cold, hard scepticism of those who forget that with the early locomotive-engines the fireman had to run along the road by the side and stoke, but as common-sense Englishmen who are anxious to know whether at the present moment the *pros* or the *cons.* are in the majority.

An electric current, as you have seen, can produce heat; but, unfortunately, not only can an electric current produce heat, but an electric current always is producing heat. Now, while it is very proper that heat should be produced in an electric lamp or furnace, it is quite out of place in the dynamo machine or generator of electricity, or in the leading wires, or in the electro-motor, which converts the electric energy into mechanical energy. In all such cases the heat produced by the electric current corresponds with the heat produced by friction in machinery, and causes the same sort of waste of power.

But this loss of power, we shall see, is not necessarily so very great even when the power has to be transmitted a considerable distance, for when there are a number of machines, lamps, or motors that have to be worked by electricity there are two ways in which they may be connected together. They may all be joined in what is technically called "parallel," or they may be connected in "series." In the first case the current, as you see from the diagrams, that passes through any one of these machines does not pass through any other, and the generator must produce a large current—as large, in fact, as the sum of all the currents passing through all the machines. In the second case, the "series" arrangement, the same current of electricity passes through all the instruments one after the other in succession, and the generator only produces a current equal to that passing through any one of them. The ordinary methods of supplying houses with water or with gas are examples of the parallel

system, because the water or gas that is supplied to any one house does not go to any other. The postman brings the letters and the boy leaves penny papers at a number of houses in parallel, while a copy of the *Times*, lent out at a penny an hour, is furnished to a neighbourhood in series.

And just as a newspaper or a book from a circulating library loses in freshness, although gaining in thumb-marks and dog-ears, when supplied to its readers in series, and as water loses head or pressure as it flows down a stream, so electricity loses its potential, or power to do work, in passing through a number of machines worked by it in series.

To work, then, a number of electric motors or lamps in the parallel system we must at starting supply a large quantity of electricity at, it may be, only a low potential or pressure, whereas if they are joined in series the current may be small but the initial pressure must be great.

In all electric railways and tramways constructed up to the present time the multiple arc system has alone been adopted. This you will see from the photographs that I will now project on the screen of all the most important electric railways yet constructed. First comes three photographs [Photos. on screen] of the small circular railway, 900 yards long, of 3 feet 3 inches gauge, laid in the grounds of the Berlin Exhibition in 1879, and exhibited in 1881 at the Crystal Palace, Sydenham; next, a photograph of the Lichterfelde Railway, near Berlin; then the electric tramway in the Champs Elysée, Paris; and that of Charlottenburg, near Spandau. The latest electric railway, the one six miles long now in course of construction at Portrush, near the Giant's Causeway, in Ireland, I shall reserve, as I shall have much to say about it in my next lecture.

[Photographs were then exhibited of the various electric railways, which were described in detail.]

But the amount of power lost in heat when a certain definite amount of power is being transmitted through a given wire is very different whether the parallel arc or the series system be adopted, because the heat produced per minute depends on the strength of the current used in the transmission, and not in the amount of power transmitted. Indeed it depends not merely on the current, but on the square of the current, so that if the current be doubled the waste of power becomes four times as great as before. Economy in electric transmission therefore requires small current, and if much power is to be transmitted, small current necessitates high potential and the motors or lamps working in series. Similar considerations apply to the transmission of power by water; to obtain great economy high pressure is absolutely necessary. The accompanying tables, taken from Prof. Perry's Cantor Lectures show the amount of loss of power when different amounts are transmitted different distances by water at an initial pressure of 700 lbs., and at 1,400 lbs. per square inch, as well as the amount lost when electricity is employed with a difference of potential between the terminals of the dynamo first of 8,000 volts, secondly of 80,000 volts.

TRANSMISSION BY WATER.

PRESSURE 700 LBS. PER SQUARE INCH AT ENTRANCE.

Horse-power given in.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		H. P. lost in 1,000 miles.
	6-in. pipe.	3-in. pipe.	6-in. pipe.	3-in. pipe.	6-in. pipe.	3-in. pipe.	6-in. pipe.
500	·125	4	1·23	40	12·5	400	125
1,000	1·0	32	10	320	100	..	..
2,000	8	256	80	..	800	..	..
4,000	64	2048	640	..	..	..	..
8,000	512	..	5120	..	..	..	..
16,000	4096	..	..	..	..	..	..
32,000	..	..	..	..	..	..	..

PRESSURE 1,400 LBS. PER SQUARE INCH AT ENTRANCE.

Horse-power given in.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		H. P. lost in 1,000 miles.
	6-in. pipe.	3-in. pipe.	6-in. pipe.	3-in. pipe.	6-in. pipe.	3-in. pipe.	6-in. pipe.
500	·015	·5	·15	5	1·5	50	15
1,000	·125	4	1·25	40	12·5	400	125
2,000	1	32	10	320	100	..	1000
4,000	8	256	80	2560	800	..	..
8,000	64	2048	640	..	6400	..	..
16,000	512	..	5120	..	..	..	..
32,000	4096	..	..	..	..	..	..

TRANSMISSION BY ELECTRICITY.

POTENTIAL 8,000 VOLTS.

Horse-power given to wire	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		Horse-power lost in 1,000 miles.	
	½-in. wire.	¼-in. wire.	½-in.wire	¼-in.wire	½-in.wire.	¼-in.wire.	½-in.wire	¼-in.wire
500	0·7	2·7	7·	27	70	270	..	..
1,000	2·7	10 8	27	108	270	..	..	..
2,000	10·8	43·2	108	432	1080	..	..	..
4,000	43·2	172·8	432	1728	..	..	..	..
8,000	172·8	691·2	1728	6912	..	..	..	..
16,000	691·2	2764·8	6912	..	..	..	..	..
32,000	2764·8	11059·2	27648	..	..	..	..	..

POTENTIAL 80,000 VOLTS.

Horse-power given to wire.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		Horse-power lost in 1,000 miles.	
	½-in. wire.	¼-in. wire.	½-in.wire	¼-in.wire	½-in. wire.	¼-in. wire.	½-in.wire	¼-in.wire
500	·007	·027	·07	·27	·7	2·7	7·0	27
1,000	·027	·108	·27	1·08	2·7	10·8	27·0	108
2,000	·108	·432	1 08	4·32	10·8	43·2	108·0	432
4,000	·432	1·728	4·32	17·28	43 2	172·8	432·0	1728
8,000	1·728	6·912	17·28	69 12	172·8	691 2	1728 0	6912
16,000	6·912	27·648	69·12	276·48	691·2	2764·8	6912·0	..
32,000	27·648	110·592	276·48	1105·92	2764·8	11055·9	..	..

But high electric potential or pressure is generally considered to mean danger to life, and series working of machines or lamps has this disadvantage, that if from any accident the current is stopped passing through one it is stopped passing through all.

The danger arising from the use of high potential can be very much diminished if instead of using the earth as part of our return circuit we employ not only an insulated wire to convey the current, but also another insulated wire to bring it back again, and if in addition the current flowing through the whole circuit is not intermittent. This may be shown by the following experiment:—Attached to these wires, well insulated from the ground, are the insulated coatings of this battery of charged Leyden jars. Now, although the difference of potentials between the wires is some thousands of volts far, far greater than is at present used, or proposed to be used, in any system of electric transmission of power, I can, as you see, touch either wire with perfect impunity. But if either of these wires be replaced by a wire in contact with the earth, say, replaced by one of the gas pipes, and I were now to touch the other, I should receive a violent shock.

As, however, my love of electric experiments does not extend to shocks, I will touch the insulated wire by deputy, using this metallic rod, and the result is, you see, a bright spark. [Experiment shown.] Both the going and return wires, therefore, should be insulated.

But next, the current flowing in them must not be discontinuous if danger is to be avoided. For if instead of keeping the difference of potentials between any two points in the two insulated wires constant I allow rapid fluctuations in this difference to take place, then, no matter how well the wires be insulated, a violent succession of shocks will be received on touching either of the wires, even although the other be not touched, so that no circuit in the ordinary sense is completed through the body. To show this experimentally I shall replace this insulated battery of Leyden jars with an induction coil which, as well as the voltaic cells used in charging it, are thoroughly well insulated from the earth in every part. Let me, however, touch either of these wires—again by deputy—and you see bright sparks passing to the earth. [Experiment shown.] Bear in mind that I am touching one wire only, not both, so that although the Ruhmkoff coil is doubtless an old friend to you, I am using it to-night in a new way to illustrate my point.

Now let us consider why it is that when a current goes and returns by a wire completely insulated from the ground no shock is experienced when the current is perfectly steady, even if a bare part of the wire be touched; but if there are rapid variations in the current strength severe shocks are felt even if only one part of the wire be touched.

In each case the effect of touching the wire is to reduce the potential of the point touched to that of the earth, and to effect a corresponding alteration of the potential along the whole line. This means the addition to, or a subtraction of a certain quantity of electricity from the wire. In the case of a perfectly steady current this operation only occurs *once* for once touching the bare wire, and unless the electrostatic capacity of the wire be very great, or the potential of the point touched immensely different from that of the earth, this *single* addition or subtraction of electricity produces hardly any perceptible feeling. But in the case of a varying current the potential of the point would naturally be undergoing constant variations of potential, so that in order to keep the point touched at the same potential as that of the earth, constant additions and subtractions of electricity are necessary, and if these occur with sufficient rapidity a severe shock is produced, even although the body forms no part of the main circuit.

A single puff of air through this syren produces no audible sound, a rapid succession of even minute puffs a loud roar; so the single small electric discharge is not perceptible, but the rapid shower of Lilliputian arrows is terribly painful. This, indeed, is the same analogy Prof. Perry employed in his lecture at the Society of Arts to prove the powerful action of rapidly recurrent effects in connection with our method of signalling to ships by means of sound waves sent through the water itself.

High potential, I have explained, is absolutely necessary for economy in electric transmission of power, and I hope I have also made it clear to you that, contrary to the received opinion, this high potential is not necessarily at all dangerous to life if the currents employed are not at all discontinuous. But the discontinuity of current we have to deal with is not merely the discontinuity that exists in the so-called reverse current machines. Even many dynamos, like the Brush, do not produce a really constant current, although generating a current of sufficient mean constancy to cause a perfectly steady deflection on one of the ordinary Ammeters of Prof. Perry and myself, an instrument, be it remembered, so dead-beat that it records with perfect accuracy the change of current produced every time the joint in the driving-belt passes round the pulley of the dynamo, as well as the regular increase of current at each of the explosions of the gas in the cylinder of a gas-engine.

The variations of current I am now referring to occur many hundreds of times a minute, and although they cannot be detected by ordinary current meters, and although but little attention has been given to them, they are in my opinion a source of great danger when the dynamo produces a high electromotive force.

In any machine for the mechanical production of electricity a coil must, as you no doubt all know, be alternately rapidly brought up to a magnet and then withdrawn. Bringing up the coil produces a current in one direction in the coil, and withdrawing it a current in the opposite; and although by a simple piece of mechanism, called a commutator, the direction of the current in the external, or useful, portion of the circuit may be always kept the same, even although the direction of the current is alternately reversed in the coil no mechanism can make the coil produce a current at the moments of rest, when it changes its direction of motion. Wheatstone, in 1841, proposed to overcome this difficulty by combining two or more dynamos in series, like the two cylinders of a steam-engine, in such a way that the current produced by the one was strongest when the current

AYRTON AND PERRY'S OBLIQUE COILED DYNAMO, ELECTRO-MOTOR, &c.

Part elevation of Armature.

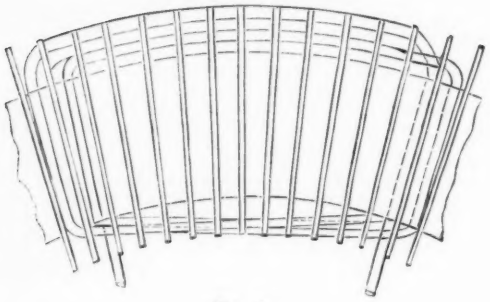


FIG. 3.

Part plan of Armature.

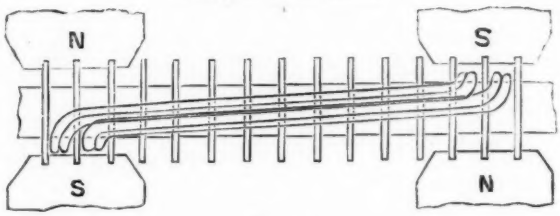


FIG. 3.

General View of Dynamo.

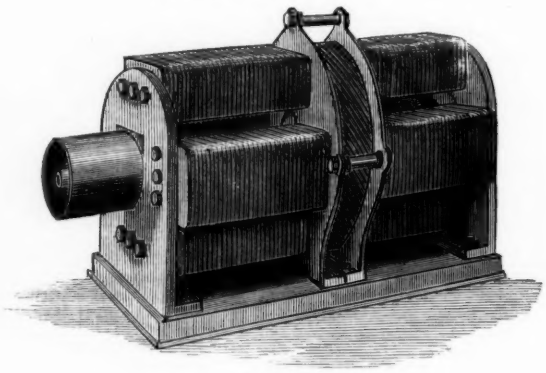


FIG. 1.

Electro-motor Commutator.

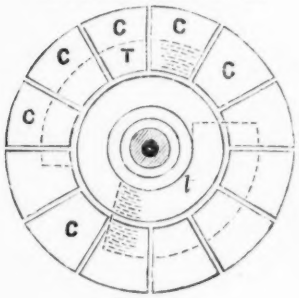


FIG. 12.

Section of Armature.

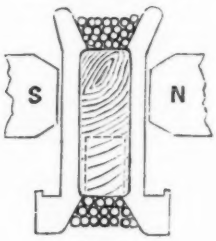


FIG. 3.

Longitudinal Section—Electro-motor.

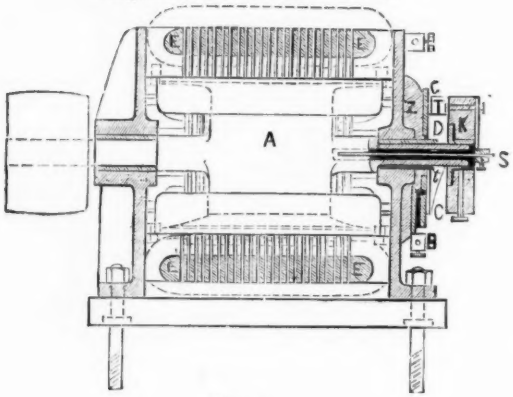


FIG. 11.

Transverse Section—Electro-motor.

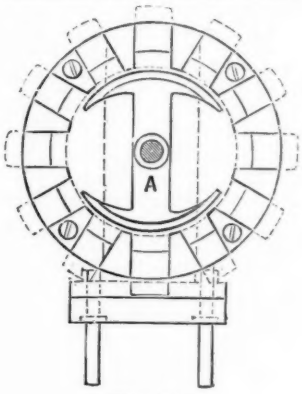


FIG. 10.

Mode of joining Coils to Commutator in Dynamo.

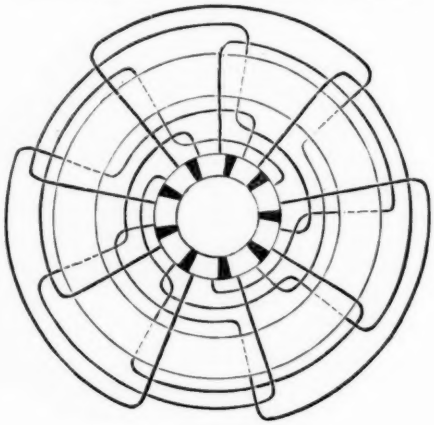


FIG. 2.

Periodic Governor for Motor.

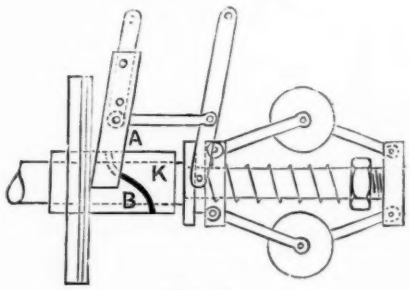


FIG. 13.

produced by the other was weakest; but Pacinotti, in 1860, showed us scientifically, and Gramme, in 1870, practically, how to combine a number of moving coils in one machine so as to give a current comparable in steadiness with that produced by a voltaic battery. The power of any dynamo depends roughly on the speed at which the coils move and on the strength of the magnetic field in which they move. Now, from the construction of the well-known Gramme machine, the strength of this magnetic field is necessarily weak when the machine is made of large size so that the greater power and efficiency which ought to come from enlarging the machine is partially compensated for by the relatively weaker magnetic field; indeed, even in a small Gramme machine the magnetic field is probably weaker than the magnetic field produced long ago in the old reverse-current machines of Holmes and Wilde. Hence more recent inventors, like Brush, have adopted a compromise between the perfect uniformity of strength of current obtained with the Gramme dynamo and the strong magnetic field in the old reverse-current machines. But in almost all the high electromotive force dynamos continuity of current has been somewhat sacrificed to strength of magnetic field. The plan, however, described in 1879 by Prof. Perry and myself of oblique coiling of the armature, shown in figures 1, 2, and 3, has enabled us, especially in our recently-constructed machines, to combine the continuity of current produced by a Gramme with the powerful magnetic field necessary for obtaining high electromotive force, and these results are in no way diminished when the machine is increased to the size necessary for utilising hundreds or thousands of horse-power and for obtaining that high efficiency which both theory and practice show is obtainable with the use of very large dynamos.

The next point to consider is how can we measure the amount of this dangerous discontinuity in the current produced by a dynamo without having to resort to the inconvenient process of killing off a certain number of people. We want a "Discontinuity Meter," and such an instrument I have here, employed by Prof. Perry and myself for this purpose. It consists simply of an induction coil in which both the primary and secondary circuits are of thick wire. The one is put in the main path of the current, the other is attached to one of our "Spring Ammeters," which measures the mean square of the strength of the reverse currents produced in the outer secondary coil by the intermittencies of the main current.

Now what are the results obtained when such an instrument is practically employed? Why we find that when a current of ten ampères produced by a three-light Brush dynamo is flowing through the primary, there is a reverse current through the secondary which increases to about five ampères, when the secondary is nearly short-circuited, and which, be it remembered, is produced merely by the commonly ignored discontinuities in the current in the main current produced by the Brush machine. On the other hand, when the same current, ten ampères, is sent through the primary by a Gramme machine running at about the same speed, no visible current, certainly not a quarter of an ampère, is produced in the secondary. Hence it is clear that the continuity of the Gramme current is immensely greater than the continuity of the Brush current.

A telephone may also be used as a discontinuity meter, the two terminals of which are in different experiments attached to two points close together in the main circuit of the dynamo. For quantitative experiments these two adjacent points in the main circuit should be selected, so that in all cases there is the same difference of potentials between them, and then the pitch of the note heard in the telephone will tell the number of variations per minute in the main current, and the loudness of the note the magnitude of such variation.

And I strongly advise any one who is procuring a high electromotive force dynamo to ascertain for himself before purchasing, the magnitude of the discontinuity factor of the machine, and about which he will find no information as a rule given in any description of the machine.

The other inconvenience arising from the use of high potential and small current, viz., that as the motors and lamps must be put in series the accidental stoppage of the current passing through one stops the current passing through all, is easily remedied by the use of what are technically called "cut outs." A cut out, as you see, consists of an electro-magnet wound with comparatively fine wire, and which allows a small part of the total current to pass through it instead of through a particular motor or lamp. If, however, from no failure in the generator, no current can pass through the motor or lamp, then more passes through the cut out, the electro-magnet of which becomes stronger than before, attracts the armature which closes this side circuit, and so allows all the current to flow by the by-pass thus formed. [Experiment shown with a circular saw and emery wheel, each driven directly with one of Ayrton and Perry's motors.]

We have seen, then, that for economic electric transmission of power high potential must be used; secondly, to avoid danger to workmen and others likely to touch the wires, both the going and return wires must be insulated, and also the current must not only be what is practically called a constant current, but must not be subject to the rapid variations in intensity such as are produced by many existing dynamos.

Next, in a satisfactory system of distribution of power, be it electric or otherwise, the supply should be exactly equal to the demand; a greater or less demand for power on the part of any consumer should not be accompanied by a less or greater supply to any other consumer of power. In the distribution of gas to a town this problem has never been completely solved. Owing partly to the mass possessed by the gas in the mains no automatic regulator has ever yet been devised to use at the gasworks so perfect that our burners do not flare at about nine o'clock in the evening, when the consumption of gas in the town is being rapidly diminished; and indeed at the present day a gas-engine in a building even fed direct from the main will cause unpleasant pulsations in all the lights in the same building, also fed directly and separately from the main, so that the number of explosions in the gas-engine can be counted all over the building. The pressure regulator at the gasworks cannot act quickly enough, so that Sugg and others have devised automatic regulators to attach to the burners themselves in the houses.

Constant pressure in the case of gas corresponds for electric lamps or motors in parallel with constant difference of potentials between the leads, and with constant current for lamps or motors in series.

As an illustration of the importance of these considerations you see this battery of three Grove's cells will light this incandescent lamp, or it will drive this electro-motor, but when I attempt to unite them in multiple arc together, the light of the lamp is, you observe, much diminished in intensity, due to the fact that the difference of potentials at the ends of the carbon filament is diminished when the motor is started. Again, I have these two lamps in series; I now allow the current to pass through a third lamp in the same series, and you observe that all the three are duller than either of the two were before, due to the current being diminished. [Exp. shown.]

And conversely, if from a sudden diminution in the consumption, arising from many of the lamps being suddenly turned off, the difference of potentials between the main wires is much increased, all the remaining incandescent lamps are suddenly broken. Indeed, when the governing of the difference of potentials or of the currents was much less perfect than at present, it was no uncommon thing for hundreds of incandescent lamps, costing many pounds, to be suddenly broken.

Consequently the problem of supplying either constant difference of potentials in the parallel system, or constant current in the series system, independently of the consumption of electric energy, and which might at first sight appear rather a dry and uninteresting problem, is in reality of great practical importance, since it must be solved before one train on an electric railway shall not suddenly start going faster because another has stopped, or before the electric lights in one train shall not become dim or break because the passengers is another train have turned theirs on or off. It is a problem, therefore, to which electrical engineers have devoted much attention during the past few years.

Two of the methods that have been devised to regulate the supply of electric energy in proportion to the demand appear to me to have all the defects of the automatic regulator at the gasworks in that they are far too sluggish. In the one plan, when the dynamo is producing less than the required amount of electric energy, so that in the parallel system the electromotive force between the main leads falls below the normal amount, or the current in the series system becomes less than the normal current, an electro-magnet is partially demagnetised, which has the effect of opening the throttle valve of the steam engine or altering the expansion so that the steam-engine, and therefore the generator dynamo, goes more quickly than before. But as it is quite possible to start a motor or turn on a lamp, or many lamps, somewhere in the circuit instantaneously, whereas it is impossible to suddenly either increase or diminish the speed of an engine and dynamo, the regulation in such a system is always considerably behind the change calling it forth.

In the second system no alteration is made either in the speed of the engine or dynamo, but a resistance is withdrawn from the main circuit or from the circuit of the exciting magnets of the dynamo; when the supply of electric energy falls below the demand, the dynamo, in fact, is made more powerful. [A large diagram showing one of the plans employed by Edison for effecting this latter object was exhibited.]

This plan of introducing a resistance is far better than the former, by which it was attempted to slow both the driving engine and dynamo, in that there is no large mass like that of the engine, the speed of which has to be suddenly changed; but it has the disadvantage that at any rate some mechanism has to be set in motion to vary the resistance, and this requires some time to effect, not to mention the difficulty of producing perfect dead-beatness in the mechanism to avoid oscillations. Also, if the exciting magnets of a dynamo are very powerful, as in the Edison machine, their strength cannot be suddenly altered by altering the strength of the current flowing round them. Hence, with this plan, again, there is a fear that the regulation may be behind the change calling it forth.

There exists, however, a third and totally different plan for governing dynamos, not depending at all on the motion of any electro-magnet, nor on anything like a mechanical governor, and which is extremely quick in its action. This third plan has been carried out in three totally distinct ways: 1st, by Brush in America; 2nd, by Deprez in France; 3rd, by Prof. Perry and myself in England.

I have said that in any machine for the mechanical production of an electric current a coil of wire must be moved rapidly in a magnetic field. Now there are four distinct ways in which this magnetic field may be produced: 1st, by a permanent magnet, in which case the generator is a "magneto-electric machine;" 2nd, by an electro-magnet, the current flowing round which is produced by an auxiliary battery or electric generator. Such a machine is said to be "separately excited." 3rd, by an electro-magnet, the current flowing round which is the main current produced by the generator itself, in which case the generator is a "series or single-circuit dynamo." And lastly, only a portion of the current generated in the moving coil may pass round the electro-magnet, in which case the generator is called a "shunt dynamo." In the two first cases, the magneto-electric machine and separately excited generator, the electromotive force depends almost entirely on the speed of motion and only slightly on the current; while in the third case it increases, and in the fourth case diminishes, with the strength of the current produced when the speed of motion remains constant.

The method employed by Brush consists in doubly winding the exciting magnets, so that the machine is both a series and a shunt dynamo. Deprez also doubly winds the exciting magnets, so that his machine partly magnetises itself, and partly is separately excited from an auxiliary dynamo. In each case two magnetic fields helping one another are produced by this double winding, and dynamos as

ordinarily constructed cannot be thus governed without being re-wound; further, if a number of dynamos in the same building are to be governed, each must be doubly wound in the manner described.

Our plan, on the other hand, for lamps and motors in parallel, and when therefore we want to obtain constant difference of potentials between the mains, independently of the number of lamps or motors that are working, consists either in combining a powerful magneto machine, M, and a small series dynamo, D, as shown in fig. 4, or a powerful shunt dynamo, M', and a small series dynamo, D, as shown in fig. 5, the field magnets of M', being a shunt to both machines. In both cases the small series dynamo, D, acts as the governor in the

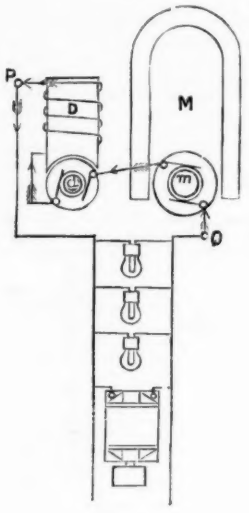


FIG. 4.

Ayrton and Perry's constant difference of potentials.

manner to be described further on, and in both cases the result of the arrangements for constant speed of the machines is to add a constant electromotive force to that produced at any moment by the regulating machine, D.

When we had the lamp and motor in parallel, why was it that the lamp burnt well when the motor was stopped, but only gave a feeble light when the motor was running? Was this due to the electromotive force of the battery diminishing when the motor ran? No; the electromotive force is constant, but a certain portion of this

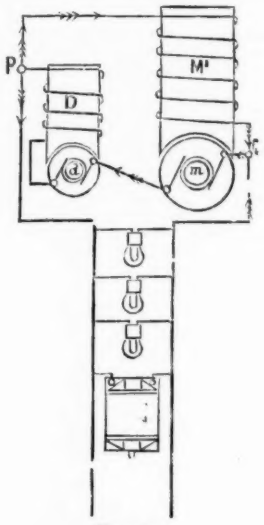


FIG. 5.

Ayrton and Perry's constant difference of potentials.

electromotive force is always being employed in sending the current through the battery itself, and the remainder only is available for sending the current through the external resistance, and the proportion of the latter to the whole electromotive force diminishes as the current sent by the particular battery increases.

As long, however, as the resistance of the battery is small compared with that of the external resistance, the current passing through any one lamp is not affected by the number of lamps put in parallel; for example, these two Grove cells make this one lamp glow, so also do they equally well make these three lamps in parallel, because in each case the resistance of the battery is less than that of the lamps. But if I put 20 such lamps in parallel, you observe only a faint glimmer. [Exp. shown.] Let me now repeat this experiment, using in the place of these two Grove's cells two Faure-Sellon-Volckmar accumulators, and what is the result? You observe I can increase the number of the lamps from one up to twenty in parallel without seriously diminishing the glow in any one of them. [Exp. shown.] If, then, we could have a magneto-electric machine with an armature possessing an excessively small resistance, but producing a sufficiently high electromotive force, one lamp or a hundred could be lighted equally well, the speed of the machine were kept constant—that is to say, the supply of power necessary to keep the speed constant would always be exactly equal to the demand for power necessary to keep any number of lamps equally bright. But in the absence of such extremely small resistance magneto machines, we must resort to some device to cause one lamp or a hundred lamps to burn equally bright, and the device Prof. Perry and I have adopted for the multiple arc system is the combination of the

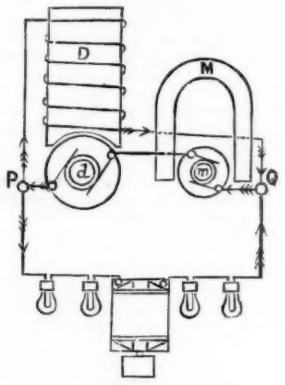


FIG. 6.

Ayrton and Perry's constant current.

large magneto machine, M, fig. 4, or main shunt dynamo, M', fig. 5, which does all the external work, and a small regulating series dynamo which does all the internal work; that is, sends the current through the dynamos itself. In fact, our combination, figs. 4 and 5, produces the same result as if the resistance of the armature, *m*, of the larger machine could be made nought without diminishing the electromotive force it can generate.

The speed of the magneto machine or of the main shunt dynamo merely depends on the type of lamp employed, and is such that if it were used *alone* with only one or two lamps, it would produce a difference of potentials between the brushes, just sufficient to make the lamps glow properly. The speed of the small governing series dynamo has nothing to do with the lamps; in fact, must be kept quite the same whatever kind of lamps or number of them are employed. The speed of this governing dynamo is what is called the "critical"

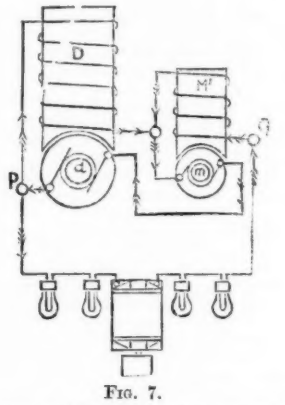


FIG. 7.

Ayrton and Perry's constant current.

speed for an external resistance equal to that possessed by the armature, *m*, of the main magneto or dynamo machine, and which means the speed a little below which the series dynamo would give an extremely small current and a little above which it would give a very great current, if the external resistance were kept constant and equal to that of the armature of the main dynamo—that is, if the external circuit were short-circuited.

This critical speed, which was first suggested by Sir Wm. Thomson, in the earliest days of dynamo machines, in a paper called "An Electrical Paradox," is of the greatest importance to us electrical engineers for governing, since it enables a very slight change of speed to convert a very weak generator into an enormously powerful one, corresponding in steam-engines with a very great change in the supply of steam for an extremely small change in the speed, the result aimed at in any good loaded governor for a steam-engine.

On examining fig. 5 it will be seen, that since the current passing round the exciting magnets of M¹ depends only on the difference of potentials between the mains, and since the whole arrangement has for its object the maintaining this difference of potentials constant, M¹ really acts as a powerful magneto machine, with constant strength of field whatever current is flowing through the mains—in fact, that arrangement (fig. 5) enables us to combine a powerful magneto machine with a dynamo without having to employ very large and heavy permanent magnets.

The rule, then, for ascertaining experimentally the proper constant speeds to run the two machines at so that a constant and desired difference of potentials shall be always maintained between the mains, whatever number of lamps or motors are in multiple arc, is as follows:—Short-circuit the external circuit by joining P and Q with a thick wire, now run the series dynamo *only*, and increase its speed until a current is just produced by it. The speed so found is the speed at which the series dynamo must always be run whatever be the kind or number of lamps employed. Next, short-circuit the series dynamo and open the main circuit by disconnecting P or Q from the main circuit, now run the magneto or shunt dynamo *only* and increase its speed until the difference of potentials between P and Q is the desired difference of potentials, then the speed so found is that at which the magnet or series dynamo must be run, no matter how many lamps or motors are employed in parallel.

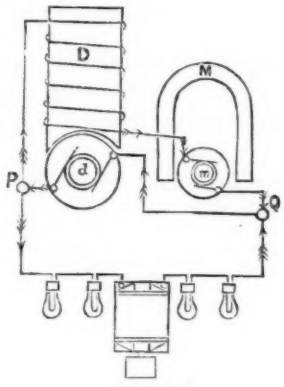


FIG. 8.

Ayrton and Perry's constant current.

If our lamps and motors are in series, so that constant current through the mains, and not constant difference of potentials, is the result aimed at, the arrangement we adopt is either that shown in figs. 6 or 7, or that shown in figs. 8 or 9. Remembering that the arrangements are for producing constant current in the mains, and that therefore the magnets, M¹, figs. 7 and 9, round which this constant current passes must be always constant in strength it will be seen from what I have said before that the arrangements shown in figs. 6 and 7 have the effect of adding a constant electromotive force to the armature circuit, *d*, of the shunt dynamo, while the arrangements shown in figs. 8 and 9 introduce this constant electromotive force in the shunt circuit, D, of this shunt dynamo.

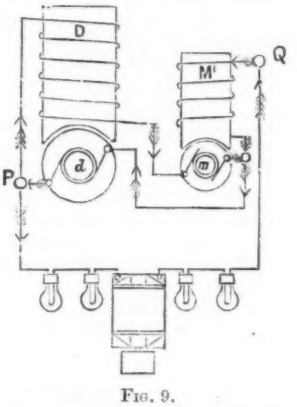


FIG. 9.

Ayrton and Perry's constant current.

In this case for obtaining constant current calculation shows that the shunt dynamo, which is the main machine, must be run at the critical speed when the main external circuit is broken, and the speed of the magneto machine is in this case such that if the external circuit were short-circuited and the shunt dynamo not turning the current produced by the magneto would be the required current. One great advantage that our method of obtaining constant difference of potentials or constant current possesses over all the others is that by means of it, without the employment of any variable resistances, electro-magnets, or any form of mechanical governor, a number of ordinarily constructed dynamos can be made to furnish a supply always exactly equal to the demand by combining with them one additional ordinarily constructed dynamo and running them at the various special constant speeds above referred to.

In the admirable Cantor Lectures recently given at the Society of Arts by Professor Silvanus Thompson, the methods employed by Professor Perry and myself for regulating difference of potentials and current were gone into far more fully than I can do here in a popular lecture, and as doubtless many among you who are electrically inclined, will read those lectures with interest, Prof. Thompson will, I am sure, pardon my giving you a word of warning about the diagrams accompanying his description, since, from some oversight, probably on the draughtsman's part, they do not represent correctly the relative dimensions of our main and regulating machines in each case. This, however, I have endeavoured to do in the symbolical diagrams shown at this lecture.

Up to the present time whenever it has been necessary to convert electric energy into mechanical energy, use has been made of a dynamo worked backwards. But a dynamo is designed for converting mechanical energy into electrical energy, and not to do the converse, therefore although every dynamo will act as a motor, Professor Perry and myself have come to the conclusion that for its weight, it is by no means the most powerful motor that can be designed. In a dynamo there is, as you all know, a large electro-magnet, which produces what is termed the exciting field and a moving armature, the current flowing through which produces another magnetic field, which in all dynamos tends to weaken the first and important magnetic field. Hence the best dynamos have been so designed that while the exciting electro-magnets produce a very strong field, the armature shall produce a very weak field.

This result has been arrived at partly by making the armature of a dynamo small compared with the exciting electro-magnets, and partly by giving it a squat form; but in a motor, we have concluded from certain theoretical and practical considerations that, on the contrary, the strengths of the two magnetic fields produced by the exciting magnets and by the armature should be equal, and since the armature, from its shape, is necessarily rather a weak magnet, whereas the field or exciting, magnet, from its shape, is a strong one, we have reversed the usual conditions of things, and made the armature large and the field magnet small, and from this we have been led to make the armature stationary and surrounding the field magnet, instead of, as usual, the field magnet surrounding the armature. This little thing, then (A, figs. 10 and 11), which I hold in my hand, and which you might at first sight mistake for a Siemens armature without the commutator, is in reality not an armature at all. In our motors the current always flows in the same direction through any portion of the wire coiled on this interior bobbin, A, which is, of course, the condition of a field magnet; while in any part of the wire coiled on E E, the stationary portion of the motor, the current is reversed in every revolution, and this is the condition of an armature. Our small field magnet then carries the brushes and revolves inside the stationary armature, the coils of which are joined to the stationary commutator, which, unlike ordinary commutators, we make flat (fig. 12, and c c, fig. 11) to save both space and expense: and in this way we have, we believe, obtained, *weight for weight*, a much more powerful motor than can be obtained by using a dynamo, as well as a more efficient motor *for its size*—that is, the ratio of electric power put into mechanical power given out is greater than in the case of a dynamo of the same size used as a motor.

I say intentionally "for its size," because not only does the horse-power of a motor increase far more rapidly than its weight when the same current is flowing through it, but so also does the efficiency. The increase of power is between the fourth and fifth power of the linear dimensions of the motor, while the weight and cost only increase with the cube. For example, one of our motors, such as there are many examples in this hall driving the various tools, weighing under 40 lbs., will produce effectively half a horse-power, while one twice as long and of twice the diameter, weighing therefore 320 lbs., or eight times as much, will produce from 8 to 10 horse-power, that is from 16 to 20 times as much. Very small motors, producing, say, one-twentieth of a horse-power, can have only quite a small efficiency, are in fact not economic converters of power, while motors producing several horse-power, experiment shows may, when properly constructed, have an efficiency of from 70 to 80 per cent. Why then ever use small motors at all if larger ones are so much more efficient? Because the total waste of power when any motor is used to drive machinery does not only occur in the motor itself, but also in the shafting employed to transmit the power to the machine, and in the belting, toothed wheels or other gearing employed at the machine itself to produce a high speed if it be a fast-speed machine. Consequently, for quick moving small tools like drills, emery wheels, small circular saws, small electro-motors are of great value, since not only does the entire absence of all intermediate gearing, but the enormous convenience of being able to bring machine-driven tools to any part of the work instead of having to bring the work to the tool far more than compensates for the efficiency of small electro-motors being less than that of larger ones. And for large quick-moving machines like fans, centrifugal pumps, screws of small launches, &c., large electro-motors will be invaluable, since they will combine high efficiency with absence of all shafting and the power of shifting the position of the motor and machine at will in the workshops. Hence I believe that for all quick-moving machines, small or large, electro-motors will play an important part in the fitting up of our workshops.

[Portable drills, emery wheels, small circular saws, as well as a fan and a centrifugal pump were then shown, each driven directly without gearing with an Ayrton & Perry's electro-motor.]

But you may have observed in these rough experiments that the motor increased in speed when the work was taken off. If this were unavoidable it would be a serious hindrance to the general adoption of electro-motors for commercial purposes. It would never do for a piece of wood or iron in a lathe to rush round when the chisel was taken off, since not only would there be a great waste of power but on next applying the chisel it would be probably broken by the wood or iron when rotating with such an excessive velocity. It would never do for the screw of an electric launch to race when the boat

pitched; this difficulty is bad enough in the present steamers, where a certain amount of racing has to be tolerated because the steam-engine cannot be perfectly governed, but with a simple electric-motor it would be much worse.

Not only, then, must we arrange, in the way I have described, that the supply of electric energy is proportioned to the demand, but also that the motors consume this energy in proportion to the work they have to do, in other words, the electro-motor must be governed so as always to run at the same speed whatever work it may be doing. The oldest form of governor for motors is what I have called the "spasmodic governor." I will show you it in action, and then you will see the reason for the name [Experiment shown]. The form I am using here is simply a mercury cup revolving with the motor driving this drill. When the mercury revolves the surface, as you all know, assumes a cup-shaped form, the centre being much lower than the edges. A wire dipping into the mercury at its centre carries the electric current into the mercury, whence it passes through the motor, but when the mercury revolves faster than at a certain definite speed the centre of the mercury becomes so low that the wire ceases to touch it, the current is then temporarily stopped, and the motor slows again until the mercury again rises to the end of the wire.

The objection to this motor is exactly the same as the objection to the ordinary governor supplied with gas-engines—either full power is supplied or no power at all. The result is that the motor slows until a certain moment, when it suddenly receives full power. It then goes off with a rush, continuing to receive full power until it goes so fast that all power is cut off, the speed then rapidly falls, and the same spasmodic action is repeated. Now what we want is, not this alternation of no power and full power, but a supply of power proportionate to the work the motor is doing at any particular moment. To attain this object, Prof. Perry and I have designed our "periodic governor," for electro-motors, a rough model of which you see in operation here, and one of the forms of which is also shown in the large diagram (fig. 13).

A brush, A, lies on the rotating piece, B K, the cylindric surface of which is formed of two conducting portions connected with one another through any resistance, and the brush, A, is moved along the cylinder, B K, under the action of the governor balls. When the brush, A, is touching the contact part, B, the motor is receiving current directly; but when A rests on the part, K, then the motor receives current through the resistance which is interposed between B and K. If the governor balls fly out, the brush is moved along B K, so that there is contact with K during a greater part of the revolution than before; and if the governor-balls come together, the speed of the motor being too small, the brush is moved in the opposite direction, so that it makes contact with B for a longer time during each revolution.

If the motors are in series, we arrange that the periodic governor shunts the currents periodically instead of introducing resistance.

In some of our motors with flat commutators the periodic governor is constructed as part of the commutator itself, to avoid the necessity of employing any separate apparatus.

With our periodic governor the power is never cut off entirely for any length of time; nor, on the other hand, is full power ever put on for any length of time, but in every revolution power is supplied during a portion of the revolution, the proportion of the time in every revolution during which much power is supplied to the time during which less is supplied depending on the amount of work the motor is doing. Our periodic governor then differs from the spasmodic governor in the same way that a good loaded steam-engine governor differs from the ordinary governor of a gas-engine.

Having perfected this governor, we then proceeded to abandon it for something better. Why does an ungoverned electro-motor run away when the load is taken off? Because it is using up more of the electric energy than it ought to? Both the spasmodic and our periodic governor operate by diminishing the supply; but there is another way of preventing its running away, and that is by using a brake of some kind to keep the load constant. When the useful work being done is small the brake-power would be large, and when the useful work is large the brake-power would be small, the sum of the two being kept constant. Such a system would obviously be practicable, but not economical, if the brake attached to the motor were to use up the surplus power in producing heat; but supposing the brake stored up the power in some form that could be easily utilised in driving the motor afterwards, then the system of braking would not necessarily be uneconomical, and if the brake was of such a kind that it acted very powerfully when the speed of the motor increased even a little above the normal speed it would be very effective.

Now, such an arrangement we have effected by combining a dynamo with the motor in a variety of different ways. The motor, as is usual, converts electric energy into mechanical energy, while the dynamo reconverts some of this mechanical energy into electric energy, which is added to that supplied by the mains; and by arranging the resistance in the dynamo circuit so that the desired speed of the motor corresponds with the critical speed of the dynamo, the brake power exerted by the dynamo becomes extremely large if the speed of the motor even slightly exceeds the prearranged speed. Here I have an experiment which illustrates our principle in its simplest form. One of our motors is geared with a dynamo, so that both run together, at a speed which is the critical speed for the resistance in the dynamo circuit. You see on putting a load on the motor I scarcely at all diminish its speed, and on withdrawing the load the speed of the motor hardly increases. But we can go further than this, for we can combine the motor and the dynamo in one machine. Consider an ordinary series dynamo—if you turn it with the brushes it produces a current, if you supply it with electricity it will run backwards against the brushes. Suppose, now, we wound it with two distinct circuits in *opposite* directions, on sending a current through one coil it would turn as a motor one way, on sending it through the other it would turn as a motor the other way. What would happen if you sent a current through both at the same time, and if one of the circuits were less powerful than the other? Why, the current passing through one would make the machine turn as a motor, producing a back electromotive force, and the current, as is usual in motors, would be checked, while the current flowing through the other circuit would be helped on, since for that circuit the machine is acting as a dynamo. Well, that is the principle of our machine. We wind it with two circuits in *opposite* directions, such that the main current passing through one of them magnetises the armature and field magnets, and so produces the motion, while the main current passing through the other demagnetises the armature and field magnets, tends, therefore, to stop the motion, and is in consequence helped on itself.

I will conclude this lecture by showing you one of the motors thus governed in action and will reserve until my next lecture, on March 15th, the consideration of the peculiar effect of the lead of the brushes in such motors, and when I shall also consider in detail the construction of the permanent way for electric railways, and of the mains where enormous potentials are employed. I shall also say something about the use of stored electricity for tramcars, boats, and tricycles, and when, if the room allows, I will show you our electrically-driven and lighted tricycle running.

CONTI'S SYSTEMS FOR NEUTRALISING THE EFFECT OF INDUCTION BETWEEN TELEGRAPH AND TELEPHONE LINE WIRES.

THESE systems are two in number, the principle of the first will readily be seen by reference to fig. 1. In this fig. A B represents the telephone wire, and A_1 B_1 the telegraph wire; at C, which may be any point along the line, the wire makes a long square loop, a portion of this loop running in close proximity to the wire, A B. Now it is evident that this

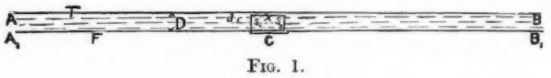


FIG. 1.

portion being in close proximity to A B, can induce in the latter comparatively powerful currents; it will also be seen that the lower part of the loop is completed by two portions of the wire running parallel and in close proximity to one another. If now we trace the course of a current in the loop of the wire, A_1 B_1, we can see that the currents flowing in the portions of the wire last referred to are in opposite directions, and being of course equal in strength they neutralise each other's inductive effect and will produce no effect on the wire A B; the portion of the loop close to A B, however, can induce strong currents in A B, but the course of the inducing current will be in the reverse direction to that in the portions of the wire on either side of the loop, consequently the inductive effect will be contrary. We have therefore an inductive effect produced by the portions of the wire, A B, on either side of the loop, and also a contrary inductive effect produced by the portion of the loop which is in close proximity to the wire, A B. There is then a short length of wire in close proximity to A B and long lengths on either side of C in distant proximity to A B, and it is evident that if we proportion the horizontal length of the loop we can cause the inductive effects referred to to exactly neutralise each other, so that currents sent through A_1 B_1 will practically produce no effect on A B.

In order to determine what length the loop should have, and how close its proximity should be to the wire, A B, we have the proportion—

$$x : \mathrm{T} + x :: d : \mathrm{D}$$

when d_1 is the distance between the wire, A B, and the portion of the loop close to A B, D is the distance between A B and A_1 B_1, T the length of the wires, A B, A_1 B_1, and x the horizontal length of the loop. We therefore have—

$$x = \frac{\mathrm{T}\, d}{\mathrm{D} - d}$$

Thus, for example, let there be a telegraph line wire running parallel to a telephone wire for a distance of 60 miles, with a mean distance separating the two, say of 20 feet, what is the length of the compensating x?

Let us first choose a convenient distance for d—namely,

the distance separating x from T, and, say, it is to be one foot, then by the equation we have—

$$x = \frac{60 \times 5{,}280}{(20 - 1)} = 16{,}673{\cdot}7 \text{ ft.}$$

which gives the horizontal length of the loop. The actual amount of additional wire required to form the complete loop will be, of course, rather more than twice this amount, or rather more than 6 miles.

Mr. Conti points out that several compensating loops, instead of one only, may be employed if preferred.

Fig. 2 shows an arrangement of the loop where several

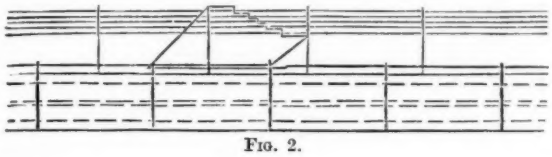


Fig. 2.

wires have to be compensated; in this case the arrangement has to be made so as to allow for the fact that each wire acts not only on the compensating wire close to it, but also on each of the others; this is effected by making the compensating portions opposite the middle wires shorter than those portions opposite the upper and lower wires. It is obvious that the general arrangement of the principle can be modified to meet any required cases.

Although in fig. 1 we described A B as the telephone wire, it is obvious that the same arrangement holds good if A_1 B_1 is the telephone wire, and similarly in the arrangement shown by fig. 2 this may represent one telephone wire and five telegraph wires, or *vice versâ*.

Fig. 3 shows the second system of neutralising induction.

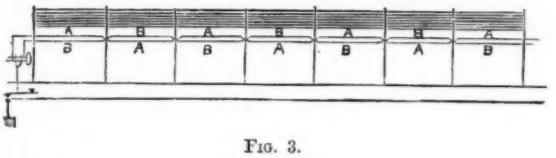


Fig. 3.

The chief points in this system are the differentially wound telephone and the use of a return wire. The double wire, it will be seen, is used as a looped circuit for carrying on the telephone communication, the telephone currents going in opposite directions through the two line wires and through the two coils of the telephone. The looped wire is, however, also used for ordinary telegraphic communication, the currents sent by the telegraphic key passing along the two wires and the two coils of the telephone in the *same* direction; thus these currents do not affect the telephone. This arrangement, however, it must be pointed out, is precisely similar to that patented by Mr. F. Jacob. (See patent specification 231, 1882, Electrical Review, August 26th, 1882, p. 159.)

REVIEWS.

Tratado de Telegrafia.—Par Don Antonino Suarez Saavedra.—Tomo II. Estudio de la Electricidad, del Magnetismo y del Electro-Magnetismo. Segunda Edicion. Barcelona: Jaime Jepus.

The first volume of this work treats, it appears, of electric telegraphy from an historical point of view. The second volume now before us deals with electricity, magnetism, and electro-magnetism, generally and scientifically, expounding their laws as ascertained by experiment and by mathematical investigation. As an instance of the truly philosophical spirit pervading the work, the author is at some pains to explain the difference between theory and hypothesis, terms which are often used without any clear understanding of their meaning, and which are consequently confounded together even by men who lay claim to a scientific standing.

The author treats in succession of the essential characters and nature of electricity, including under this head its importance, its definition, and principal character; the general causes of its production and the elementary notions of potential and of the circuit. Hereupon follows a discussion on the nature of electricity, in which are noticed the unitary hypothesis of Franklin, the dualistic hypothesis of Symmer and Coulomb, and the various theories derived from the unity of physical forces. The second chapter is devoted to the generation of electricity, of magnetism, and of their reciprocal actions.

Chapter III. treats of the systems and instruments of electric measurement, including descriptions of electrometers, ordinary galvanometers, tangent and sine compasses, reflection and differential galvanometers, rheostats, Wheatstone's bridge, &c.

In the fourth chapter the author speaks of the procedures for electric measurements. Chapter V. deals with the machines and apparatus for generating electricity, such as friction machines, electro-static induction machines, magneto-electric, dynamo-electric, and electro-magnetic machines, hydro-electric batteries, thermo-electric and secondary piles.

We come lastly to the charge and the distribution of electricity in bodies, and to a consideration of the circuit and the electric current, the resistance to its passage, the laws of Ohm, Kirchhoff, and Lenz, and to the speed of electricity.

The author of the work is evidently well acquainted with the most recent developments of electric science. His descriptions are full and clearly written, whilst the illustrations—145 in number—are intelligible and moderately well drawn. We are not aware of the existence of any modern work on electricity in the Spanish or the Portuguese language of equal merit. When it is remembered that there are three volumes to follow, treating respectively of the description of the telegraphic systems with a summary of the remaining practical applications of electricity, of the construction of telegraphic lines, and of their maintenance and service, it will, we think, be admitted that Don Antonino Saavedra has conferred a great boon upon the physicists, telegraphists, and engineers, not merely of the Iberian peninsula, but of Mexico and South America.

Berly's British, American, and Continental Electrical Directory and Advertiser.

Last week we briefly alluded to Mr. Berly's volume for 1883 with the above title. The book is a handsome imperial octavo of 664 pages, very well arranged and most clearly printed. From the title one might be led to believe that the work is a directory and advertiser pure and simple, but it is in reality something more, for it contains a considerable amount of information, valuable alike to the scientist and to the practical man. We may mention, amongst other matter, Remarks on the Past Year, Tables and Formulæ, British Electrical Publications, Publications of the United States Patent Office, Summary of Patents bearing on Electricity, Magnetism, &c., Rules and Regulations as regards Fire Risks for Electrical Installations, &c., &c. Mr. Berly's Directory is divided into a number of sections, and the British and foreign sections are classified in a clear way. Allowing for some trifling errors, which will doubtless be erased from a second edition, we can cordially commend Mr. Berly's admirable production, which should secure a place amongst the books of reference belonging to all connected directly or indirectly with the progress of electrical science. A feature in its pages is a complete list of the officers and members of the Society of Telegraph Engineers and of Electricians.

The Anglo-American Brush Electric Light Corporation, Limited.—Sir Henry W. Tyler, M.P., has, we understand, resigned his seat on the Board of this company. It will be remembered that at a recent meeting of the corporation Sir Henry stated that he was not willing to remain at the head of a "dissatisfied" body of shareholders. The vice-chairman having been elected to fill the post has consented to temporarily act as chairman.

TO CORRESPONDENTS.

No notice can be taken of anonymous communications. Whatever is intended for insertion must be authenticated by the name and address of the writer, not necessarily for publication, but as a guarantee of good faith.

Letters, &c., for the "Correspondence" columns should arrive not later than Tuesday morning if they are desired to appear in the following number, such communications to be addressed to the "Editors," ELECTRICAL REVIEW, 22, Paternoster Row, London, E.C.

Letters respecting Advertisements, Subscriptions, &c., should be sent to the "Publisher," ELECTRICAL REVIEW, at above address.

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CORRESPONDENCE.

The Electric Lighting Act.—Provisional Orders.

You will allow me to point out in reference to your note on my letter in last week's journal, that 1,000 ampères flowing for one hour under the pressure of a volt is equivalent to 3,600,000 watts, and not, as you appear to say, simply 1,000 watts.

If you are regarding the measure as 1,000 watt hours, it is not the same as 1,000 watts, which is C. G. S. measure, to the simplicity of which it appears to me to be wise to adhere in the measure of electrical energy.

E. W. Beckingsale,
General Manager and Electrician, Brush Electric Light and Power Company of Scotland, Limited.

[We need not do more than refer Mr. Beckingsale to the letter of our correspondent "E.," which appeared in our columns last week. A second letter from Mr. Beckingsale has reached us, but too late for insertion.—EDS. ELEC. REV.]

Electric Light Conductors.

In your last issue you draw particular attention to the limit for conductivity laid down for distributing mains and service lines in Mr. Fletcher Moulton's regulations, and ask for opinions on the subject. I have had some experience with large currents, and am of opinion that an insulated wire of a round or square section of one square inch area would be excessively heated by a current of 2,000 ampères. Still more would one of two square inches in section be heated by a current of 4,000 ampères. At the same time I know that a similar wire 1-100th square inch section will safely take a current of 20 ampères; even a wire of circular section and 1-10th inch diameter will do this, and hence 100 such wires making up a total sectional area of one square inch would safely take the 2,000 ampères laid down. The fact appears to me to be that the current should not be laid down with reference to the cross-section alone, which of course determines the resistance, and therefore the work done in the wire and amount of heat produced per unit of time, but also with reference to the surface exposed by which this heat is dissipated.

When a wire is heated by a current, the temperature to which it rises above the surrounding medium is determined by the condition that the current of heat flowing into the medium is equal to the rate at which heat is produced by the electrical current.

If we take the case of two wires insulated in air through which are passing currents of c and c^1 respectively, sufficient to maintain each wire at a temperature, θ^0, above the air, let their cross-sections be a and a^1; then their resistances per unit of length are proportional to $\frac{1}{a}$ and $\frac{1}{a^1}$

Let the perimeters of their cross-sections be p and p^1, then their surfaces per unit of length are p and p^1. The work done per unit of time in these wires is proportional to

$$\frac{c^2}{a} \text{ and } \frac{c'^2}{a^1}.$$

The heat radiated per unit of time is proportional to

$$p\,\theta \text{ and } p^1\,\theta,$$

Or $$\frac{c^2}{a} = b\,p\,\theta, \frac{c'^2}{a^1} = b\,p^1\,\theta,$$

where b is some constant

$$\therefore c^2 : c'^2 :: p\,a : p^1\,a^1.$$

Or for any wire the current it can safely conduct varies as

$$\sqrt{p\,a}.$$

Of course when the wires are covered with an insulating substance, which is also a bad conductor of heat, the conditions are complicated with considerations of the thickness and nature of the substance. Thus, if the substance liquifies at a temperature which otherwise would be regarded as safe, a serious accident might result.

If the thickness of dielectric be proportional to that of the conductor, it appears to me that the law would still hold good. For the same size of conductor a thicker dielectric would offer more resistance to the passage of heat, and would tend to raise the temperature of the conductor, but the outside of the dielectric would be cooler than a thinner one would be.

On the whole, I think the fairest rule to adopt would be something similar to the following:—"For conductors having a conductivity of at least 90 per cent. of that of pure copper, and of uniform cross-section, the current conveyed by them in ampères must not exceed 500 times the square root of the product of the cross-section in square inches, multiplied by the perimeter of cross-section or circumference of wire in linear inches." This rule gives for a conductor of square section conveying 2,000 ampères, a sectional area of about 2·5 square inches, and for a square conductor 1-100th inch thick a current of 1 ampère. Other metals, such as iron, would naturally require a different constant.

I submit this rule with diffidence, as I am not aware that any similar rule dealing with the temperatures produced by currents in wires has yet been propounded, but I think it has been noticed before in your columns that it is not the work done in the wire alone that has to be taken into account in determining the resulting temperature; indeed, I think some experiments have been lately published showing that the temperatures in ordinary wires of round section are more nearly inversely as the first power than the second of the diameter. My theory would make them inversely as the diameter to the power of $\frac{3}{2}$.

P. C.

[We have much pleasure in inserting our correspondent's letter, with the hope that many of our other readers may be induced to take up this very interesting matter. The selection of conductors will probably be the most important item for electric lighting companies to consider, and a series of tables similar to that compiled by Mr. Robert Sabine (see ELECTRICAL REVIEW of January 6th), but dealing with covered wires, would be most valuable.—EDS. ELEC. REV.]

Cost of Electric Lighting.

Since January, 1882, a large railway station in this state has been lighted by electricity. The current is furnished by a 40-light Brush dynamo machine of the usual construction, and is run by a 50 H.P. (nominal) engine. All the machinery and apparatus were new, and made to order for this purpose. The Brush lamps, surrounded by globes, are

of the arc type and of the usual pattern. Everything was made of the best materials, and was put up in the best manner by experienced workmen.

The installation was put in on approbation, and for several months was operated by the contractors, a local (Brush) electrical company. The lighting having proved satisfactory, the installation was in April bought by the railway company, and to this date has been in successful operation nightly, no accident of any nature having occurred.

The running expenses having been cut down to the minimum, and the *employés* having become able to produce the best results, the following statement of the running expenses for four months—June, July, August, and September, 1882—may be found interesting :—

	Dols.
Attendance (two men)	633·90
Fuel (coal)	952·26
Oil and waste	45·50
Repairs	81·42
Carbons	322·40
Globes	39·10
Brushes	7·50
Total cost	2,082·08
Average cost per month...	520·52
Average cost per night	17·6
Average number of lights nightly, 30·9	
Average hours of lighting nightly, 5	
Average cost of one light nightly ...	55 cents.
Average cost per light per hour... ...	11 cents.

No luminous, mechanical, or electrical measurements of the installation have been made ; but, under all the circumstances, it is fair to assume that there is not more than the usual waste of energy.

The local opinion seems to be that, while the station is brilliantly illuminated by electricity, and better than gas could possibly do it, yet that *sufficient light* could be obtained from gas for half the money.

Samuel Purnell.

San Francisco, California, U.S.A.,
January 31, 1883.

The Elphinstone and Vincent Machine.

I am very sorry that Mr. Vincent made any reference to my galvanometer, which was designed and made in the days when there was a difficulty in getting one of Messrs. Ayrton and Perry's instruments for so large a current ; but in justice to Messrs. Ayrton and Perry, I should like to say that their instruments can now be obtained, of any desired calibration, from Messrs. Paterson and Cooper.

I may add, that I was totally unaware that Mr. Vincent was going to pay me any compliment or say anything about my instrument, and I have written the above to prevent any unintentional damage being done to Messrs. Ayrton and Perry's interests.

Francis J. Mudford.

[With the insertion of Mr. Mudford's letter, we hope that all further reference to the experiments on the above machine will cease, at least until we can publish a new series of tests.—Eds. Elec. Rev.]

Science Lecture in Edinburgh.—On Tuesday evening Mr. J. H. A. Macdonald, Q.C., Dean of the Faculty of Advocates, A.S.T.E. and E., &c., delivered the first of two lectures on "Electricity ; its Characteristics and Uses." The subject, which was treated rather popularly than scientifically, was listened to by a very large audience with appreciative attention. The hall was lighted by means of one of an improved form of pendant Brush lamp and a number of Lane-Fox incandescent lamps fed by Faure-Sellon-Volckmar accumulators. This, it may be remarked, was the first public exhibition in Edinburgh of incandescent lighting, and was received with cheers. Mr. Frederick White, of London, had charge of the installation, which was most satisfactory.

NOTES.

Electric Lighting.—Messrs. J. Edmundson and Co., 19, Great George Street, Westminster, London agents for the Swan United Electric Light Company, are exhibiting at the Royal Aquarium Exhibition about 200 Swan incandescent lamps of various sizes, from two to 50 candle-power. These light their court, a portion of which is divided off and furnished as a complete modern drawing-room. Messrs. Edmundson and Co. specially draw attention to their samples of new patterns in electroliers, brackets, and various fittings for carrying incandescent lamps, which they have taken much pains in designing, as well as switches, cut-outs, &c., and all appliances for fitting up complete installations for large mansions, &c. The current for maintaining these lights is derived from a Siemens 200-light alternating-current machine and exciter, worked from the main shafting in the engine-room. This firm also exhibits a Faure-Sellon-Volckmar accumulator, or storage battery, for maintaining the lights in the drawing-room, the charging current being supplied by a Siemens direct-current dynamo machine, driven by a 3½ horse-power "Otto" gas-engine, which is worked by means of Dowson's gas, manufactured in the exhibition by the Dowson Economic Gas Company. The whole of the furniture and fittings are carried out by the exhibitors, being either manufactured by them or expressly for them. Messrs. Edmundson and Co. likewise show from one of the outside towers a 4,000 candle-power arc light, in a first order dioptric lens, as used for lighthouse purposes. The current for this is obtained from a gramme machine, and a Serrin lamp is used.

The Gülcher method of electric lighting has just been introduced at the Lambton Drops, Sunderland, and in future, vessels, it is said, may be loaded during the night with as much ease as at noon. To a town like Sunderland Gülcher's low tension arc system, in combination with Crookes' incandescent lamp, presents many valuable qualities, the safety and steadiness of the light offering the greatest advantages. The illuminating power of the Gülcher arc lamp is equal to a thousand candles, and that of Crookes' incandescent lamp to twenty candles, and the whiteness and purity of the light is unquestioned. Each arc lamp is arranged to burn for sixteen hours without requiring attention.

The Camberwell Vestry met on Wednesday week, when the clerk reported the receipt of a letter from the Board of Trade, acknowledging the receipt of the vestry's statement of the objections to the proposed Camberwell and Penge electric lighting provisional order, and also copies of amendments and clauses that the vestry desire to have inserted in such order ; also stating that if the order be proceeded with an inquiry will be held, of which 10 days' notice will be given, at which an opportunity will be given to the vestry of stating their objections.

An amusing incident occurred on Thursday evening, last week, in connection with some experiments carried on at Messrs. Unwin Brothers' printing office, Little Bridge Street. At about half-past eight o'clock the neighbourhood was suddenly and brilliantly illuminated by a glare from the first-floor windows. A cry of "Fire" was instantly raised, and the neighbouring fire escape and a pair of engines were speedily on the spot. The street was thronged with people, but the firemen soon found out that they were not wanted. The cause of the disturbance was the lighting up of a very powerful "Search light," as used by the navy, capable of giving a light equal to 100,000 candles, the carbon of which is 1¼ inch in diameter. This lamp was maintained by a current from a dynamo patented by Lord Elphinstone and Mr. C. W. Vincent, and described recently in the Electrical Review.

The Edison Company has received permission from the Commissioners of Sewers to continue the lighting of Holborn Viaduct for one year from the 24th ult.

The Sperry Electric Light Motor and Car Brake Company has been formed in Chicago, with a capital of 1,000,000 dols., to develop the inventions of Mr. Elmer A. Sperry and will at once proceed with the development of its various systems, one of the most important of which is that relating to the electric light. The leading feature of this is

said by Mr. Sperry to be that of self-regulation, or the automatic control of the currents. According to American advices it is claimed that the dynamo to be used realises more current from the power applied than other existing machines, and that the company will, therefore, be able to produce the light more economically than has hitherto been done. Small motors will be used in connection with the lighting system, in driving light machinery, elevators, &c. The application on street cars, Mr. Sperry says, is one of the most promising features of the system.

The Kremlin, Moscow, at the forthcoming coronation of the Czar, will be illuminated by 40 electric lamps giving a light equal to 400 candles each. Electrical engineers from England have arrived there to aid in fitting up.

The Edison Electric Light Company, says the New York *Evening Post*, is steadily increasing the number of lamps in use in its down-town district, and is now lighting 310 houses, wired for 6,225 lamps. The trouble with the engines at the central station has been overcome. Meters are in all the buildings where the light is used, and bills are presented regularly. They are about the same in amount as the gas-bills were for a similar light. Although serious trouble was experienced some months ago with the engines, the light has been furnished night and day, without a moment's interruption, since the 4th of last September. The street mains have proved to be as free from leaks as was expected, and the company is confident of being able to supplant gas all over the district, and make money at the price paid to the gas companies.

The Force and Light Company, controlling the storage battery patents of the French inventor, Faure, are at present engaged in legal warfare with an English company claiming to have rights in the Faure patents, and with the Brush Company, which has lately put a storage battery, said to have been invented by Mr. Brush, into the market. The Brush Electric Light Company have made common cause with the Swan Electric Light Company of England against the Edison Company, which latter organisation is suing the Brush Company for using a lamp (Swan) somewhat like Edison's, while the Force and Light Company is suing because Brush wants to light his Swan lamps from a battery which resembles Faure's.

Mr. Farrer, the Secretary to the Board of Trade, at a meeting of gentlemen interested in electric lighting, held at the Board of Trade on Saturday week, made a statement as to the general conclusions the Board had arrived at. They wished the local authorities to act for themselves. If two companies applied for the same district the Vestry must select the company. The Board would have no bogus companies. The area of supply chosen by the company must be restricted. The company and the Vestry must agree on the area, and the Board would see that the company had enough means to work the area selected, and the money required must be set aside for that district. As regards the company's profits, and as to any portion of that profit going to the public, the Board would not listen to such a suggestion. The price must be regulated by competion with the gas company, and, if necessary, with other electric companies. Provision for safety against fire must be left to the public, the company, and the fire insurance companies. No meter had yet been found to satisfy the Board; but when one was found it would be introduced. Model clauses would be prepared by the Board and issued to the public to promote uniformity.

Tenders, we notice in the *Contract Journal*, are invited for lighting by electricity the new docks at Tilbury. Particulars are to be had of Messrs. Kirk & Randall, contractors, Woolwich.

The Metropolitan Brush Electric Light and Power Company v. Cruikshank.—This action, which was by the company against a shareholder for calls, he setting up as a defence fraudulent representations in the prospectus, came before Lord Justice Brett, Lord Justice Cotton, and Lord Justice Bowen, in the Court of Appeal of the High Court of Justice on Tuesday. The effect of the alleged misrepresentations was that the company had the sole and exclusive use of the dynamo machines and "arc lights" and the Lane-Fox incandescent lamps; whereas, in truth, it was said they had not so. The company, treating the case as without defence, took judgment, but a Divisional Court had set it aside, and given the defendant leave to defend upon an affidavit by him, and the company appealed. Mr. Mellor, Q.C., and Mr. Bower appeared for the company; Mr. Rose-Innes and Mr. C. G. Hyde were for the defendant. The contention on the part of the company was that their prospectus did not contain the statement objected to. In the result, the defendant was let in to defend the action on condition of bringing the money into Court.

The Electric Carbon, Storage, and Apparatus Manufacturing Company of Scotland (Limited), on Wednesday week, received instructions to fit up throughout the s.s. *Buninyong*, now lying in Sandon Dock, Liverpool, with incandescent and arc lamps, and the work is being proceeded with.

Electric Lighting Competition.—It is reported that the Brush Electric Light Company has challenged the United States Electric Light Company to a public contest of their systems in Louisville, Kentucky. The loser is to pay £200 towards the expense of the exhibition and £500 to the Polytechnic Society of Kentucky. We would suggest that the same "sport" should be encouraged here. The numerous companies might be handicapped by some competent person, and the losers in the "trial heats" should be made to withdraw from the field altogether. The three or four competitors remaining for the final struggle might then be allowed to withdraw their stakes, and we should expect some really good and substantial progress to be made in electric lighting.

Contemplated Electric Exhibition in Philadelphia.—The Franklin Institute of Philadelphia contemplates holding an Exhibition this year, which will be exclusively devoted to electricity, magnetism, and their related sciences.

The International Electric Exhibition at Vienna. According to an official information, directed to his Excellency Count Wilczek, Honorary President of the Electric Exhibition, his Imperial Highness the Crown Prince Archduke Rudolphus of Austria has graciously condescended to take the patronage of the International Electric Exhibition in Vienna, 1883, and on this occasion to express the warmest interest for this enterprise, as well as the progress to be hoped for in connection with it. His Imperial Majesty the Emperor Francis Joseph has been pleased to order, by his Highness Prince Hohenlohe, the artistical establishment of Carl Giani to produce a pavilion for the electric exhibition. This pavilion is, according to the intentions of his Imperial Majesty, for the purpose of demonstrating the effects of electric light on richly worked draperies and embroideries. According to the plans already in progress, this pavilion, for which the exhibition is entirely indebted to the munificence of his Majesty, will be of considerable dimensions, and carried out in a pure architectural style well suited for the purpose, and richly decorated with precious stuffs. It will be at the same time a very showy object of exhibition, as well as a very interesting one for obtaining experiences. In respect to the latter, it will be arranged for the alternative application of different systems of electric light in order to show their relative effects.

The extent of the Vienna Electric Exhibition may be estimated by the fact that the motive-power to be employed is about 1,000 horse-power, 700 of which is to serve for lighting the Exhibition buildings and grounds. The boilers and engines for the production of the motive-power will in general be of the fixed type, not, however, excluding portable boilers and engines; these will, at the same time, be objects of exhibition. It has been proposed to arrange the boilers and steam-engines almost in the same way as for permanent service, so that they may be the more satisfactorily inspected by the visitors. The machine department will prove a great attraction to the public generally, and will also afford a good opportunity to engineers to make valuable comparative studies. Although such an arrangement will considerably add to the expenses, nevertheless the Commission has consented to sacrifice a greater amount of money than it would otherwise do, in order to give an opportunity for general instruction, and thus bring the important question how to construct boilers and engines for

electro-technical purposes more and more to the front. Two important firms in the boiler line have each offered, as objects of exhibition, all the boilers required for the production of the 1,000 horse-power. The Commission, in addition to these valuable offers, is in possession of numerous applications for the exhibition of boilers, and is ready to accept still more in order to show the merits of the different systems.

Launch of a Telegraph Ship.—The steamer *Viking*, which has been built by Messrs. Pearce Brothers, of Dundee, for the Western Brazilian Telegraph Company, was launched on Tuesday week last from their patent slip. She will be ready for her trial trip in a few days.

The Queensland Post and Telegraph.—We have just received a very neatly executed Christmas and New Year's card from the Queensland Post and Telegraph Department, containing the names of the officers of the department and many interesting statistics of its revenue and expenditure, its telegraph messages and telegraph lines, &c. On the card are views of Brisbane, Townsville, Bowen, and various prominent buildings.

Personal.—Mr. Jocelyn T. F. Otway has joined the board of the London and Globe Telephone and Maintenance Company, Limited.

The Hon. Sydney Carr Glyn, M.P., has joined the board of the Hammond Electric Light and Power Supply Company, Limited.

Mr. J. S. Sellon has been appointed chairman of the Anglo-American Brush Electric Light Corporation, *vice* Sir Henry Tyler, M.P., resigned.

Winding-up Petition.—To-day a petition for the winding-up of the Electric Carbon Company, Limited, is to be heard.

Electrical Railways.—The Court of Common Council at their meeting last week agreed to petition against the Charing Cross and Waterloo Electric Railway Bill in Parliament.

A Neglected Source of Revenue.—Under this heading our daily contemporaries are suggesting to our civic rulers the propriety of following the example of their brethren of the capital of Pennsylvania. It appears that Philadelphia derives an annual revenue of £2,400 from telegraph, telephone, and electric light companies, for the use of its overhead and underground wires. Each company makes a return annually of the number of poles, &c., and a payment of £1 per annum for each mile of wire used for telegraph or telephone purposes, and £3 per mile per annum for electric lighting purposes is required. There are at present about 10,000 miles of wire in the city.

Lubricator for the Commutators of Dynamos.—A new invention has been patented by Mr. Levi P. Dollison, of Wabash, Ind., for lubricating the commutators of dynamo-electric machines, to prevent the brushes from cutting into the commutators. The invention consists in a rocking frame provided with rollers to which bands saturated with oil are attached, and with other rollers over which the bands pass. One of these rollers, to which the bands are attached, is provided with a ratchet wheel with which a fixed pawl spring engages, which rotates the roller when the frame rocks, thus winding the bands from one roller to the other, so that a fresh surface of the bands will come in contact with the commutator every time the frame rocks. The frame is rocked by an eccentric wheel operated from the dynamo shaft.—*Scientific American.*

OFFICIAL RETURNS OF ELECTRIC COMPANIES.

Electro-Amalgamator Company (Limited).—The return of this company, made up to the 9th inst., was filed on the 16th inst. The nominal capital is £20,000, in £100 shares; 90 shares have been taken up and the full amount called thereupon. The calls paid amount to £7,170, and unpaid to £1,830. Registered office, 37, Tower Chambers, Finsbury Pavement.

Lancashire-Maxim-Weston Electric Light Company (Limited).—The return of this company, made up to the 5th inst., was filed on the 13th inst. The nominal capital is £100,000, in £1 shares, the first issue being limited to 50,000 shares; 24,038 shares have been taken up, including in this number 10,000 shares issued to the parent company as part of the purchase consideration. The full amount has been called upon each share, the calls paid amounting to £16,574 7s. 6d., leaving £7,463 12s. 6d. unpaid. Registered office, 56, New Broad Street.

CITY NOTES, REPORTS, MEETINGS, &c.

Submarine Telegraph Company between Great Britain and the Continent of Europe (Limited).

THE half-yearly meeting of this company was held at the offices of the company, 2, Throgmorton Avenue, London Wall, E.C., on Wednesday. Sir James Carmichael, Bart., the Chairman of the company, presiding.

The Chairman, at the outset, expressed his regret that the board was so badly represented at the moment. The directors who were members of Parliament had a morning sitting that day, and were consequently absent. He, however, hoped they would be present before the end of the meeting.

The Secretary, Mr. S. M. Clare, having read the notice convening the meeting,

The Chairman affixed the seal to the register of shareholders.

The report, which was held as read, was as follows:

The accounts for the six months ending 31st December, 1882, exhibit an increase of the receipts, when compared with those of the corresponding period of the year 1881, while on the other hand, some additional expenditure has been incurred, principally in repairs to cables, and under the head of salaries and wages.

The repairs have been more costly in consequence of the insertion of several miles of new cable, where some of the interruptions have taken place, and an increase of salaries and wages is owing to the establishment of additional circuits, and the consequent employment of more clerks, which became necessary to insure the prompt transmission of the additional number of messages.

The result of the business for the last half-year enables the directors to add the usual proportion of 10 per cent. of the gross receipts to the reserve fund, which will then amount to £116,126 0s. 6d., and to recommend a dividend at the rate 18½ per cent. per annum.

All the cables in the Channel and in the North Sea, worked by the company, are in good order, with the exception of the two cables between this country and Holland, which are at present interrupted, but the engineer is at Lowestoft with the company's steamer, awaiting favourable weather to repair them.

The Chairman said: I have much pleasure in moving the adoption of the report and accounts, which, I trust, you will find satisfactory. Though we have not been enabled on this occasion to recommend quite so large a dividend as we did at our last meeting, this is easily accounted for; in fact, by looking at the report you will see that one of the principal items in the increase of our expenditure is that of repairs. The expense of the repairs is onerous, owing to the very exceptional state of the weather. As you know, we have had a series of storms and gales, which not only caused damage to our cables, but very much delayed the operations of our engineer in carrying out the repairs. In the North Sea, for the last two or three months there has scarcely been a sufficient interval of calm weather to admit of any constant work. Our engineer, after being on the ground at work for a few hours, has been driven to seek shelter at Lowestoft and at other points, and I think all this fully accounts for our extra expenditure. This extra expenditure is one of those circumstances which telegraph property, and especially submarine telegraph property, must occasionally be subjected to, and over which directors have no possible control. Notwithstanding these drawbacks, our traffic would have been considerably greater than it is had it not been for the unsettled state of our friends on the other side of the Channel—the unsettled state of politics in France—which, indeed, has prevented very much not only speculation on the Bourse but has to a certain extent paralysed the commercial interests of that country. You may have gathered that from the large and influential deputation of merchants and tradesmen who waited on M. Grévy lately with a view to better matters. I need not point out to you that a want of business on the French Bourse affects us and diminishes our traffic, because our best customers are over there. Notwithstanding these difficulties we have had to contend with I do not think the traffic, as traffic, has been at all bad, for I find that the figures show that during the past half-year we carried no less than 1,422,178 messages. That is not at all a bad half-year's business, and it is 69,352 in excess of that of the corresponding half-year. The number of messages, however, does not always show an increase of profit, because sometimes you get a number of short messages; but, at any rate, these figures show to my mind a steady increase, and it would have been larger had it not been for the circumstances I have mentioned. I think I have now accounted to you for this diminution of ½ per cent. on the dividend for the half-year (hear, hear). Looking forward to the future, I think I will be able to give you some little encouragement. A very important feature has just occurred in regard to the working of this company's business, and that is with regard to press wires. You are aware that we lease special wires to the press, but hitherto that has been confined to English newspapers. Three of our princi-

pal leading papers are clients of ours—namely, the *Times*, the *Telegraph*, and the *Standard*. They lease special wires from us over which comes the great mass of telegraph matter which you read in their columns every morning. But now, I am happy to say, the foreign press, which have hitherto never taken any interest at all in, or paid to any extent for, telegraphic news have come forward, and we have concluded an arrangement with a French paper, *La Réforme*, an able paper edited by M. Waldeck Rousseau, whose name is mentioned as the probable future Minister of the Interior in the new French Cabinet. He has made arrangements with us for the lease of a special wire, and here is his paper [showing paper] which has now been going on for some days with telegraphic despatches. This is important as to the future, because it is certain to lead to other arrangements of a similar nature. Already we have another journal beginning negotiations of something of the same sort, and I hope, in the next few months, to see this system further developed. I do not think I have any further observations to make. I shall be happy to answer any questions in respect to the report and accounts.

Mr. Boys seconded, and,

The motion was unanimously carried.

The Chairman next proposed the declaration of a dividend at the rate of 18½ per cent. per annum.

Mr. Capper seconded, and

This motion was likewise unanimously adopted.

The Chairman: That concludes the business of the meeting

Mr. Castle Smith asked to be allowed to make a few remarks. They were kind enough to allow him to do so on a former occasion. What he wished to call the attention of the meeting to was the subject of their reserve. When he first joined the company it struck him that their reserve was too small, and he desired to renew the subject, not by way of opposing the directors, but for the benefit, as he believed, of the shareholders both present and future. On a former occasion the reserve had been for a short time 5 per cent. on the gross receipts, and he suggested that it should be 10 per cent., and after a very friendly consideration of, and discussion on the subject his suggestion was not opposed, but, on the contrary, before the meeting closed the 5 per cent. was increased to 10 per cent. On the present occasion he would venture to submit to the company, and every individual in it, that they should consult their interests still more if they were to increase the percentage from 10 to 15. They had but a short life to live now, unless by-and-by—and no one looking to the country could say how they would stand in the future—they had their institution renewed, but assuming that they had not and they expired at the end of about six years, it was a very short time to live to build up their interests. He believed 15 per cent. would not bring them back their capital; but still it would go a very long way to bring to their coffers the capital which they were introducing into the concern. He hoped the directors would not consider he was interfering with their office (cries of "No, no" from the directors). He merely desired, as one of a body whose interests were all alike, to make the suggestion that it might be reduced to a resolution. If 15 per cent. were added to the reserve fund it would put them in a very improved position, especially with regard to the future. He refrained from making a motion, because he was on that side of the table. He calculated, in making these observations, technical matters would not interfere, but that the subject would be handled and discussed with deliberation and with due regard to the interests of all. He should be very glad to see the 10 per cent. reserve increased to 15, and he was led to the belief, if such were done, it would not interfere with their dividends at all, and would prove a great benefit in the future.

The Chairman: I am sure we are much obliged to Mr. Smith for bringing this matter forward. What he has said is good sense. I have always been in favour of the largest possible amount of reserve fund. I have always been an opponent of its being reduced, and I am happy to say that it is now again 10 per cent. If the shareholders desire to raise it to 15 per cent., we shall be only too happy to carry out their wishes. It is quite a shareholders' question, and it is for yourselves to decide. We could not take any action at this meeting.

Mr. Smith: If the Chairman will permit me I will make my suggestion a motion to be seconded and dealt with in the usual way.

A Shareholder recommended that the directors should take the suggestion into their consideration.

Mr. Smith: I am of opinion that a motion should be put to this meeting.

Mr. Campbell: It is not a resolution which, if passed at this meeting, would have a legal effect, but if it is the opinion of the shareholders that 15 per cent. should be added to the reserve fund the directors will put it in their accounts, and if the accounts are passed the 15 per cent. will remain.

Mr. Rains asked if it would not be better to leave the question over until their next meeting, and the directors, in issuing their report, could say that in consequence of a desire expressed by some of the shareholders that the reserve fund in the future should be 15 per cent., a resolution would be moved to that effect, so that all the shareholders would have an opportunity of expressing their opinion on the subject. He thought altogether it was rather hasty to suggest so considerable a change of that kind, and adopt it without giving all the shareholders an opportunity of expressing their opinion on it.

The Chairman pointed out that it would be very much the same whether they put the 15 per cent. in the next accounts, or whether notice was given of a motion to increase the 10 per cent. to 15 per cent.

The Hon. Ashley Ponsonby said it was purely a shareholders' question. He quite endorsed every word said by Mr. Smith as to the advisability of having a large reserve fund. It would put them in a better position, and, what was more, it would make their shares stand better in the market. (Hear, hear.) But still he thought such a resolution ought not to come from the directors, but from the shareholders.

Mr. Smith: The question will be argued upon the report.

The Hon. Ashley Ponsonby: Exactly.

Mr. Smith wished them to be consistent. When they raised the percentage from 5 to 10 it was done in a particular way. He thought they should adopt the same course as they did before; but still he was quite satisfied so long as it went into the accounts and the question was raised before the accounts were passed. He would move a resolution to that effect.

A Shareholder seconded.

Mr. Rains said the difficulty with him still remained. The increase to 10 per cent. on a previous occasion he thought a very reasonable increase; but he was of opinion that it might be a question with many of the shareholders whether they would not think they were going rather too far in moving that 15 per cent. out of the gross receipts should be added to the reserve fund. He himself did not express an opinion on the matter, but he thought every shareholder should have an opportunity of expressing his opinion and voting calmly and deliberately before such a motion was carried. He thought it would be more prudent, and more in accordance with public business, if the gentleman who moved the resolution gave notice (cries of "No, no"). He was expressing his own opinion, and he thought every shareholder was entitled to express his own opinion (hear, hear). He thought, as he had said, that it would be more in accordance with public business that notice of the proposed alteration should be given to the shareholders, so that at the next meeting they might come prepared to speak and vote on the question. It had been suggested by gentlemen on the other side of the table that there was no difficulty whatever in making out their accounts; they could appropriate the additional 5 per cent. and make up their dividend accordingly; but would it not somewhat alter the state of the accounts and make some confusion?

The Chairman: It would.

Mr. Rains thought that was the question that ought to be taken into consideration One gentleman had told them that there were about six years yet to run of the continuance of their present monopoly. If they added 5 per cent. it, with the accruing interest, would make a difference of about £25,000. Their reserve fund at that moment was £116,000 or £117,000. Their capital was only £338,000. The 10 per cent. amounted to £50,000, so that if they adopted the motion, at the expiration of the six years they would have more than one-half of their capital in reserve. He thought they should act cautiously, and have time to mature their judgments, and therefore he would move as an amendment, "That the further consideration of this subject be adjourned until our next half-yearly meeting."

A Shareholder seconded.

Mr. Soden remarked that really they were putting by another reserve by keeping their cables in good repair.

The Chairman: No doubt we are.

Mr. Soden, continuing, said, among the working expenses he saw "depreciation of stores and leases £442 15s. 1d." He presumed a portion of that represented the sum yearly put aside to recoup the sum expended on the leasehold property? If so, there was another small reservation fund.

The Secretary: Yes. But it represents also the depreciation on the stores, instruments, &c., at Dover and elsewhere.

Sir Thomas Dakin was of opinion, considering the small number of shareholders present, that it was only fair that the motion should be put after proper notice. There would be no great delay in putting off the matter till their next meeting.

The Chairman said he was in favour of an addition to the reserve fund; but he thought it would be better to accept the amendment, so that all the shareholders might have notice and it be discussed at their next meeting.

Mr. Rains asked if the proposed increase from 10 to 15 per cent. would come as a recommendation from the directors?

The Chairman: No.

Mr. Rains thought that should be clearly stated.

The Chairman: The resolution will simply be put at the foot of the report.

Mr. Rains only wanted words inserted in the amendment to make the point clear.

The following amendment was then unanimously agreed to—"That due notice be given to the proprietors at the next half-yearly meeting that for the future 15 per cent. of the gross receipts, as from 1st January, 1883, be added to the reserve fund instead of 10 per cent."

A vote of thanks to the Chairman and Directors concluded the meeting.

The United Telephone Co. v. Hebden.—In the Chancery Division of the High Court of Justice on Thursday, before Mr. Justice Fry, a motion was made in this action to commit the defendant to prison for breach of an injunction of the Court restraining him from manufacturing, selling, letting for hire, or using any telephones in infringement of the Bell patent. The action was commenced in July last, but some delay occurred in consequence of the representation, since shown to be inaccurate, that the Hickley receivers, in respect of which the proceedings were taken, had been returned to the manufacturers, Messrs. Harrison, Cox-Walker and Co., of Darlington. Judgment was therefore not obtained until the 15th of December. It was stated that the defendant had contracted with two gentlemen in Oldham to have telephonic communication between their offices and residences, and that after trying Husband's instruments the defendant substituted the Hickley receiver. For the defence, affidavits were produced to show that the Hickley receivers were borrowed by the defendant's firm without his knowledge and were used without his consent. The defendant appeared in person and apologised to the court for what had occurred. His lordship was of opinion that there had been a gross contempt of court in disobeying the injunction, and made an order committing to prison the defendant with costs.